EDUCATION and NEW DEVELOPMENTS

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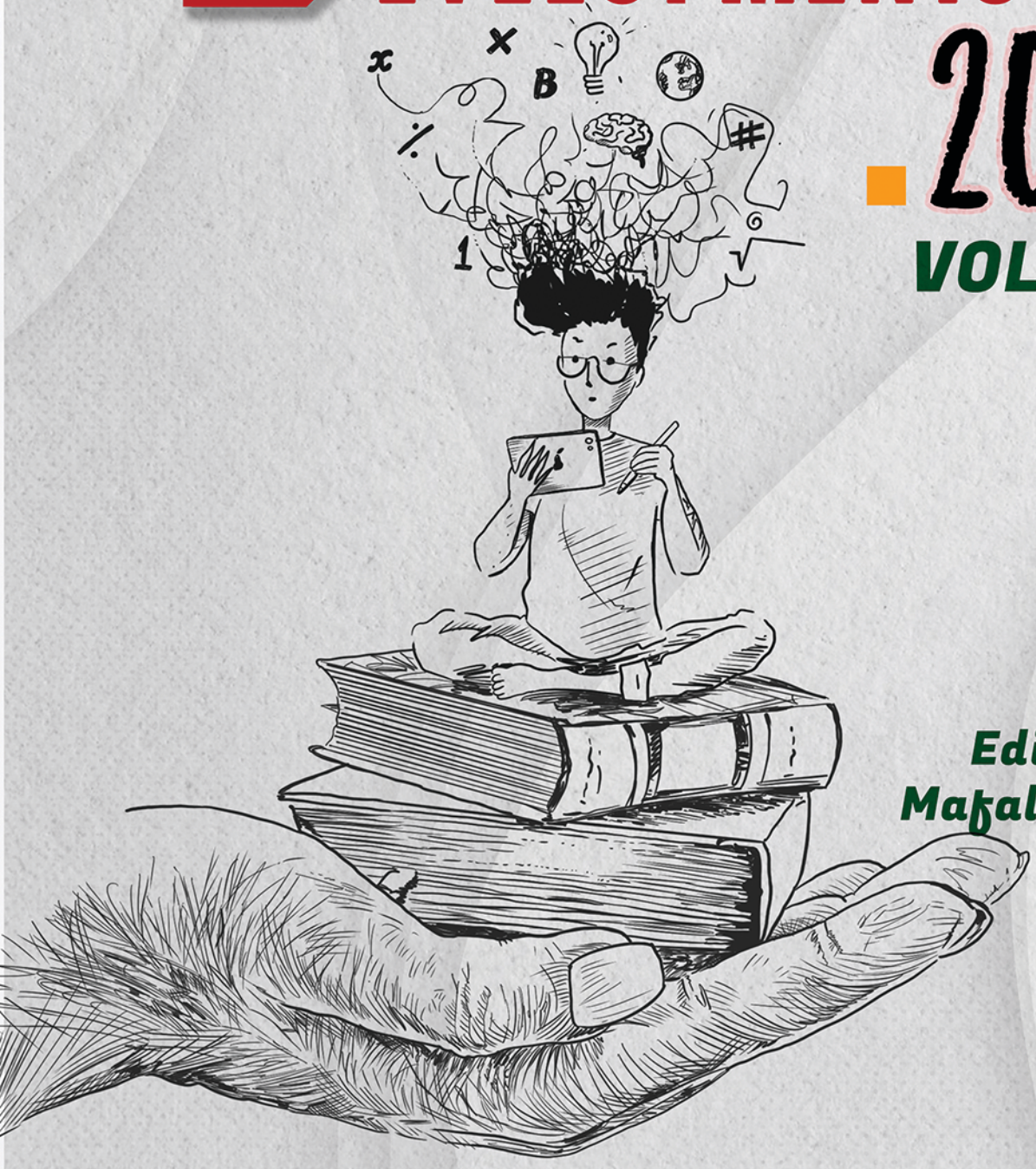

Edited by
Mafalda Carmo

WIARS
World Institute for Advanced Research and Science

Education and New Developments 2026

Volume 2

Edited by

Mafalda Carmo

Edited by Mafalda Carmo, World Institute for Advanced Research and Science (WIARS), Portugal

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FOREWORD

Dear Colleagues,

This book contains the full text of papers and posters presented at the International Conference on Education and New Developments (END 2026), organized by the World Institute for Advanced Research and Science (WIARS).

Education is a fundamental right that accompanies us from the very beginning of our lives. It encompasses every experience we encounter, influencing and shaping our thoughts, emotions, and actions. Whether we engage in formal education within classrooms or learn from the world around us, the process of acquiring knowledge plays a vital role in our personal growth and development. It equips us with the tools to navigate the complexities of life, broadens our perspectives, and empowers us to make informed decisions. This International Conference seeks to provide some answers and explore the processes, actions, challenges and outcomes of learning, teaching and human development. Our goal is to offer a worldwide connection between teachers, students, researchers and lecturers, from a wide range of academic fields, interested in exploring and giving their contribution in educational issues.

We are delighted to have successfully facilitated connections among academics, scholars, practitioners, and individuals who share a common interest in a field abundant with fresh perspectives, ideas, and knowledge. Our event has attracted a diverse range of contributors and presenters, enriching our understanding of human nature and behavior by showcasing the influence of their unique personal, academic, and cultural backgrounds. This diversity is a testament to the international reach of our conference, fostering multi-disciplinary collaborations and fostering intellectual growth and exchange.

END 2026 received 883 submissions, from more than 48 different countries, reviewed by a double-blind process. Submissions were prepared to take form of Oral Presentations, Posters, Virtual Presentations and Workshops. For presentation, the conference accepted 344 submissions (39% acceptance rate).

The conference also includes one Keynote presentation by Prof. Pedro Isaias, Universidade Aberta (Portuguese Open University), Portugal. We would like to express our gratitude to our invitee.

This conference addressed different categories inside the Education area and papers are expected to fit broadly into one of the named themes and sub-themes. To develop the conference program, we have chosen four main broad-ranging categories, which also covers different interest areas:

• In **TEACHERS AND STUDENTS**: Teachers and Staff training and education; Educational quality and standards; *Curriculum* and Pedagogy; Vocational education and Counselling; Ubiquitous and lifelong learning; Training programs and professional guidance; Teaching and learning relationship; Student affairs (learning, experiences and diversity; Extra-curricular activities; Assessment and measurements in Education.

• In **PROJECTS AND TRENDS**: Pedagogic innovations; Challenges and transformations in Education; Technology in teaching and learning; Distance Education and eLearning; Global and sustainable developments for Education; New learning and teaching models; Multicultural and (inter)cultural communications; Inclusive and Special Education; Rural and indigenous Education; Educational projects.

• In **TEACHING AND LEARNING**: Critical, Thinking; Educational foundations; Research and development methodologies; Early childhood and Primary Education; Secondary Education; Higher Education; Science and technology Education; Literacy, languages and Linguistics (TESL/TEFL); Health Education; Religious Education; Sports Education.

• In **ORGANIZATIONAL ISSUES**: Educational policy and leadership; Human Resources development; Educational environment; Business, Administration, and Management in Education; Economics in Education; Institutional accreditations and rankings; International Education and Exchange programs; Equity, social justice and social change; Ethics and values; Organizational learning and change, Corporate Education.

The contributions were published across two volumes, and this book represents Volume 2 of Education and New Developments 2026. It showcases the outcomes of innovative research and development efforts undertaken by authors committed to advancing teaching, learning, and the practical applications of education in contemporary contexts. Within its pages, you will find a diverse array of contributors and presenters of contributors and presenters who expand our understanding of educational matters by sharing their unique personal, academic, and cultural perspectives. Through their valuable insights and experiences, they enrich our exploration and contribute to the growth of educational discourse in our contemporary world.

This second volume only focuses on the main area of PROJECTS AND TRENDS, being the contributions of the other three areas published in Volume 1.

We would like to express thanks to all the authors and participants, the members of the academic scientific committee, and of course, to our organizing and administration team for making and putting this conference together.

Hoping to continue the collaboration in the future.

Respectfully,

Mafalda Carmo
World Institute for Advanced Research and Science (WIARS), Portugal
Conference and Program Chair

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KEYNOTE LECTURE

"AI AND THE DIGITAL TRANSFORMATION OF HIGHER EDUCATION ASSESSMENT"

Prof. Pedro Isaias
Universidade Aberta (Portuguese Open University), Portugal

Abstract

Artificial Intelligence (AI) is increasingly influencing how assessment is designed, delivered and interpreted in higher education. Its use extends beyond the automation of grading to areas such as formative assessment, personalised feedback, adaptive learning, learning analytics, academic integrity and student support. At the same time, the growing integration of AI into assessment raises important questions concerning transparency, accountability, privacy, bias, academic judgement and the credibility of evidence of student learning.

This keynote examines the adoption and non-adoption of AI-enabled assessment in higher education through a comparative study conducted in 2024 and 2026. It explores how university teachers' perceptions, practices and intentions regarding AI-supported assessment have evolved during a period of rapid technological and institutional change. Particular attention is given to the purposes for which AI is being used, the perceived benefits and barriers associated with its adoption, and the factors that continue to influence lecturers' willingness to incorporate AI into assessment practices.

The keynote also examines the distinctive capabilities of key categories of AI-enabled assessment technologies, illustrated through representative tools such as adaptive learning platforms, automated grading systems, intelligent tutoring systems, plagiarism-detection tools, learning analytics platforms, learning management systems and secure digital assessment environments.

The presentation concludes by addressing the institutional policies, professional development, transparency mechanisms and forms of human oversight required for responsible adoption. It invites participants to reflect on how higher education can redesign assessment while preserving academic integrity, teacher–student relationships and trust in qualifications in an environment where human and artificial intelligence increasingly interact.

Keywords: *Artificial Intelligence, higher education, assessment, Generative AI, academic integrity, digital transformation, teacher perceptions, educational innovation.*

Biography

Pedro Isaías is an associate professor with Habilitation at Universidade Aberta (Portuguese Open University) in Lisbon, Portugal. Previously, Pedro was an associate professor at the Information Systems & Technology Management School of The University of New South Wales (UNSW – Sydney), Australia, an associate professor at The University of Queensland, Brisbane, Australia, and an invited professor at ISEG-University of Lisbon, Portugal. At Universidade Aberta, he is currently responsible for several courses in the Information Systems areas and also a member of the coordination team of the postgraduation in Digital Innovation and Business Analytics. At Universidade Aberta, Pedro was director of the master degree program in Management / MBA and also director of the master degree program in Electronic Commerce and Internet for 10 years. He is co-founder and president of IADIS – International Association for Development of the Information Society, a scientific non-profit association. Author of several books, book chapters, papers and research reports, all in the information systems area, he has headed several conferences and workshops within the mentioned area. He has also been responsible for the scientific coordination of several EU funded research projects and has had participation as a principal investigator in various research projects. Currently he conducts research activity related to MIS in general, and more specifically Learning Technologies, Data Analytics, Business Intelligence, Digital Transformation, e-Business and WWW related areas. Pedro has more than 198 publications: 34 journal papers, 76 conference papers, 11 authored books, 33 edited books, 24 book chapters, and 21 journal special issues. Pedro has delivered 35 keynote/invited talks & workshop panels and has received over 4.793 citations, resulting in an h-index of 35 (Google Scholar, February 2026).

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ORAL PRESENTATIONS

GATHERING CONTENT VALIDITY EVIDENCE FOR A MATHEMATICS AND STATISTICS DIAGNOSTIC TOOL USING QUALITATIVE METHODOLOGY

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Abstract

Competence in mathematics represents an ongoing challenge for higher education institutions, particularly as universities face evolving educational policies that espouse principles of competence-based education. This means it is crucial to ensure incoming students have adequate mathematical and statistical foundations for academic success across a wide range of disciplines. Unfortunately, very few standardized diagnostic instruments currently exist to measure the mathematical readiness of entering students or to identify learning gaps that could lead to failure at an early stage of their university trajectory. The present study was developed within the framework of the DiagnosticaMATH Innovation Project, whose main aim is to create a standardized diagnostic instrument to measure the mathematical and statistical cross-cutting competence of Spanish students at the moment of entering university, and to evaluate their evolution during the years of study. The present work describes the first phase of this project, which consists of obtaining validity evidence based on test content through qualitative methodology. To this end, three discussion groups were formed with experts in mathematics education and evaluation, until saturation of the proposed themes was reached. The analysis leads to three principal results: a) a single test can hardly evaluate specific mathematical skills, but a diagnostic task could be constructed through problem solving situations involving metacognitive processes; b) comprehension is a key transversal competence, which critically affects mathematical performance; c) while the pre-university education of the students offers a sufficient base of knowledge, it is generally procedural and superficial, depending little on flexible capacity for problem solving.

Keywords: *Mathematics diagnostic test, competencies, pre-university mathematics, standard test.*

1. Introduction

The development of mathematical reasoning constitutes an essential competence for effective learning in mathematics and for constructing critical knowledge among higher education students (Büchele & Feudel, 2023). The ability to reason, validate results, formulate conjectures, and develop a deep understanding of concepts is crucial for addressing complex problems and advancing in technical and scientific fields of study (Zhao, 2020).

However, a growing mismatch has been observed between the mathematical skills students bring to European universities and the level of knowledge those institutions expect. This trend is documented in recent reports from the Programme for International Student Assessment (PISA; European Commission, 2024), which show that the proportion of 15-year-old students failing to reach adequate mathematical proficiency (i.e., interpret ratios or solve linear equations) is approximately twice the expected level.

This deficit persists into first-year calculus and statistics courses (European Commission, 2025). Moreover, the gap is not fully remedied upon entry to higher education, leading universities to report increasing enrollment in remedial mathematics courses within certain STEM programs, in some cases nearly doubling since 2010 (Büchele & Feudel, 2023). In the Spanish context, a similar pattern is evident: secondary-school mathematics does not consistently prepare students for the analytical demands of university-level programs, and as a result, more than 30% of incoming undergraduates require tailored academic support in foundational topics (Ayuga-Téllez et al., 2023). This competency gap reveals a fracture in the educational transition, where assessment and access mechanisms fail to both capture and consequently foster the reasoning skills that university studies demand.

Specifically, curricula and teaching practices frequently prioritize content memorization, procedural application, and problem-solving, while argumentation, proof, and critical reasoning receive less attention (Bhattacharya, 2022). As a result, domain-specific knowledge (Stemler, 2012) is overemphasized, crowding out the cross-cutting competencies that matter for learning mathematics (López-Agudo et al., 2024). This gap between stated educational goals and actual classroom practices results in students entering university with insufficient competencies to cope with higher-level mathematics, where learning requires a formal, structured approach grounded in logical reasoning (Deeken et al., 2020; Faúndez et al., 2017; Hed et al., 2025; Tenorio et al., 2015; Zhao, 2020).

The lack of a psychometrically valid diagnostic test of pre-university mathematics, as well as the lack of a rigorous theoretical model of this construct, leaves HE institutions without reliable and comparable information about the actual mathematical competencies of their first-year students. Consequently, any diagnostic effort tends to be fragmented and non-standardized, preventing a systematic assessment of the problem at the program, faculty or university level, and thus hindering the justification of resources for providing the appropriate support to students.

For this reason, it is essential to develop diagnostic instruments that help (1) identify the potential mathematical competency needs of students entering university studies, and (2) promote effective learning in mathematics throughout the university cycle. This development requires obtaining validity evidence to justify the intended use of test scores (AERA et al., 2014). A first, fundamental, and frequently overlooked step is to gather validity evidence based on test content, which involves examining whether the test adequately represents the intended domain or construct through expert judgment (Sireci & Faulkner-Bond, 2014). Concretely, focus groups are a technique for exploring complex concepts, building consensus among experts, and clearly defining evaluation dimensions, competency indicators, and appropriate item types (Molano et al., 2021).

2. Method

The main objective of this study is to identify the key elements to include in a diagnostic tool measuring the mathematical readiness of entering students from the lecturers' perspective. Fulfilling this objective is the first step towards building a diagnostic test of pre-university mathematics. To attain this target, we used a qualitative focus group methodology. Participants for the focus groups were selected following two main criteria. First, a quota system was implemented to ensure each group included professionals with varying levels of experience, from junior to senior practitioners. Second, all participants were required to be currently engaged in mathematics teaching at the secondary or higher education level and to demonstrate recognized expertise in their field. In total, 21 experts took part, distributed into groups of four to ten members to promote productive discussion and interaction (Ritchie et al., 2017). Regarding gender distribution, the sample comprised 17 men and 3 women. Regarding professional experience, 13 participants were classified as junior professionals and 8 as senior practitioners. Participation was voluntary, and no incentives were provided.

An interview protocol was designed to explore participants' perspectives on the current state of mathematical competence among first-year university students. Specifically, the protocol aimed to identify emerging competencies and indicators to help diagnose potential learning needs across students' academic trajectories in higher education. Ethical approval for the study was granted by the Ethics Committee of Universidad Loyola Andalucía (May 6th, 2025), Ref. No.250325-CE 25588.

Once the evaluation protocol was approved by the Ethics Committee, the focus group sessions were conducted in quiet classrooms and facilitated by two moderators who maintained a neutral and unbiased stance throughout the discussions. All sessions were audio-recorded for subsequent transcription. Recruitment of experts concluded after the fourth session, once thematic saturation was reached (Charmaz & Belgrave, 2002).

For data analysis, a qualitative framework for narrative transcription was applied, following the procedures outlined by Creswell and Poth (2016). The process comprised several sequential stages: (1) data management (transcription); (2) reading, coding of emerging tool elements (e.g., [PrInt] for Interpretation Problems); (3) describing, adding indicators, and narrative information to each element; (4) interpreting, developing an analytical template; and (5) representing, through inter-group agreement (IGA) for each indicator). All stages were monitored through peer review by three researchers to ensure methodological rigor and consistency.

3. Results

The experts' responses enabled the identification of 12 emerging tool elements. Detailed information regarding these two, including their definitions, codes, and illustrative narratives, is presented in Table 1.

Table 1. Emerging Tool Elements Identified in the Focus Groups.

Tool Element	Illustrative Narrative	IGA
Interpretation Problems: connect various topics, globally involve students (PrInt)	Conceptual-level questions. That unit vector…what is it doing? No need to calculate it, but at least understand because there's a vector, you know where it's going, what it means. They should know the concept of vector, the concept of a function that symbolizes this function.	1
Interpret the results (Interpret)	They must understand the concept of a vector and the concept of a function, including what that function represents.	1
Understanding of statements (CompLec)	They should have understanding of the language. Know what they're being asked, what data they have, and which data are relevant.	1
Infer, reason, deduce (Inferir)	Typical questions such as those involving multiple similar diagrams where participants identify which diagram does not fit or what is missing, among similar tasks.	1
Mathematics (Mat)	Calculus, algebra, including operations with fractions, as well as very basic first-degree and second-degree equations, to check if they can solve them.	1
Direct Problems: Problem solving with explicit procedure (PrDir)	Present a series of data and have them apply the formula.	.75
Application Problems: what do I need to do, what should I do (PrApl)	A modeling exercise, involving extracting a mathematical model from a problem statement and selecting the most appropriate strategy, which could be graphical.	.75
Analysis: critical graphic-spatial interpretation (Graf)	Perhaps framed as data interpretation or graph interpretation, something slightly more abstract that reveals critical reasoning.	.75
Verify (Comprobar)	Examine the result and reason whether it is correct or not, because by simply observing how nature works, you can intuit whether it is accurate.	.75
Inverse Problems (PrInv)	You can also set it up the other way around. You can write on a sheet how the three integrals are done and then include the three integrals. Let's see if they're able to understand that mathematically, that you've written it there to solve it later.	.50
Transversality: relate and connect topics (RelCont)	If I change the rules there, the student must examine all the possible ways of combining them, even if they have never encountered them before.	.50
Written Expression (ExpEsc)	I would conduct an interview with them and have them write it out on the spot while drafting it.	.50

The tool elements are displayed in descending order of inter-group agreement (IGA), with perfect consensus (IGA = 1.00) on the top five: (1) Interpretation Problems (PrInt), (2) Interpret the results (Interpretar), (3) Understanding of statements (CompLex), (4) Infer/reason/deduce (Inferir), and (5) Mathematics (Mat).

4. Discussion

From the discussion across the different focus groups, it was evident that there was consensus on the current decline in comprehensive reading competencies. For mathematics lecturers, it is clear that exercises with a statement that involves reading more words are generally perceived as more complicated, regardless of the task's difficulty. These results are in line with the PISA report 2022 (European Commission, 2024).

Secondly, there was consensus that students do not have the appropriate level of competency in the foundations of algebra and arithmetic, as reflected in the learning outcomes from secondary education. Examples of these include: lack of fluency in manipulating and operating with fractions and indices, difficulty in solving linear and quadratic equations, and understanding the fundamental concepts of elementary functions, such as the equation of a line and its applications.

Regarding the syllabus of pre-university mathematics, lecturers considered that the content taught is sufficient, but the problem stems from the teaching and learning method, which seems reduced to a set of procedures and methods, rather than understanding the fundamental concepts of mathematics, which unable students to acquire more sophisticated skills such as abstraction, inference, logical reasoning, analysis, and critical thinking.

In terms of what to include in a standard diagnostic test, questions regarding the fundamentals of algebra and arithmetic are definitely one of the core parts of this diagnostic. Secondly, competency in matrix algebra and precalculus is sought; thus, questions on these topics are generally preferred but should be tailored to different levels to differentiate the level and range of skills applied (as mentioned in the focus groups). Lastly, their comprehensive reading and writing competencies should be tested within this diagnostic test.

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REIMAGINING ASSESSMENT: AI-DRIVEN STRATEGIES FOR TRANSFORMING TEACHER EDUCATION

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Abstract

This paper presents findings from a research project investigating innovative curriculum-based assessment models that integrate Generative AI tools into pre-service teacher education. Engaging over 700 students across diverse teaching programs, the study explored how future educators experiment with, adapt, and critically evaluate the use of Generative AI in classroom and applied learning contexts. Students documented their AI usage, provided critical justification, and reflected on their experiences through structured assignment responses. Key findings reveal that when critically embedded into assessment design, Generative AI can significantly enhance students' confidence, digital literacy, and pedagogical adaptability. The process of monitoring and reflecting on AI use fostered deeper critical engagement and ethical awareness. Importantly, the study highlights the role of educative assessment redesign in transforming teacher preparation, positioning AI not as a threat but as a pedagogical partner. Implications for higher education include the need for robust assurance frameworks to manage AI-integrated assessments, professional development for educators, and policy guidance to support ethical and effective AI use. The paper concludes with recommendations for sustaining the integration of emerging AI technologies in teacher education, ensuring alignment with both academic integrity and future classroom realities.

Keywords: *Generative AI, assessment, academic support, AI pedagogies.*

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1. Research design

This study used a mixed method study design, which allowed for an in-depth exploration of the phenomenon within its real world context. An open-ended survey was chosen because it enabled the researcher to examine complex processes and behaviours that could not be fully understood through quantitative methods alone.

2. Participant selection

The participants were selected using purposive sampling. It was chosen because it aligned with the research questions and offered opportunities for rich, detailed analysis. Selection criteria included relevance to the topic, accessibility of data, and the potential to generate meaningful insights.

Participants were identified based on their direct connection to the case. These included:

- 700 Pre-service teachers
- physical or digital artefacts such as assignments
- observations of behaviours or interactions

Participants were recruited through purposive or convenience sampling to ensure they had firsthand knowledge of the AI use in teaching.

3. Data analysis

The thematic analysis was applied to teaching practice by considering how students' patterns of AI use reflect their learning needs and the pedagogical opportunities available to educators. The themes highlight several areas where teaching can be strengthened to support students' academic development while promoting ethical and transparent engagement with AI tools.

Students' reliance on AI for productivity and efficiency underscores the importance of explicitly teaching academic processes rather than assuming students will acquire them independently. When students use AI to summarise texts, reduce word counts, or organise information, it suggests a need for targeted

instruction in academic literacy skills such as note taking, synthesising sources, and structuring written work. Embedding these skills within curriculum design can help students develop greater autonomy and reduce over dependence on automated tools.

The frequent use of AI for language support particularly among students for whom English is an additional language indicates the value of integrating explicit language scaffolding into disciplinary teaching. Providing sentence frames, model texts, vocabulary support, and opportunities for guided practice can help students build confidence in their linguistic abilities. Rather than replacing human instruction, AI can be positioned as a supplementary tool that reinforces, rather than substitutes, language learning.

Students' use of AI to enhance academic writing quality highlights the need for direct instruction in academic voice, coherence, and paraphrasing. Many students turn to AI to refine tone, improve clarity, or avoid repetition, which suggests that these aspects of writing require more explicit modelling and feedback within the classroom. Teaching students how to critically evaluate AI generated suggestions can also foster metacognitive awareness and strengthen their independent writing skills.

The use of AI for brainstorming and idea development reflects students' need for structured support during the early stages of assessment tasks. Educators can respond by incorporating guided planning activities, collaborative discussions, and scaffolded brainstorming exercises that help students generate and organise ideas before drafting. This reduces the likelihood that students will rely on AI to interpret task requirements or determine the direction of their work.

Students' use of AI to clarify assessment expectations indicates that instructions and criteria may not always be sufficiently transparent. Providing annotated exemplars, unpacking rubrics in class, and encouraging dialogue about assessment expectations can reduce confusion and promote academic integrity. When students understand what is required, they are less likely to seek clarification from AI tools.

Sixth, the reliance on AI for referencing and citation support highlights the need for explicit teaching of academic integrity practices. Many students appear uncertain about how to reference correctly or how to acknowledge AI use appropriately. Embedding referencing instruction, offering practical workshops, and providing clear guidelines on acceptable AI use can help students navigate these expectations with confidence.

Finally, the presence of students who either minimally used AI or did not use it at all raises important considerations regarding equity. Not all students possess the same level of AI literacy, nor do they equally understand institutional expectations around AI use. Ensuring that all students receive foundational instruction in responsible AI use can help prevent disparities in academic performance and promote fairness across the cohort.

Collectively, these themes suggest that AI use in student writing is not merely a technological issue but a pedagogical one. By addressing the underlying learning needs that drive students to use AI whether for language support, writing development, task comprehension, or educators can design learning environments that foster both academic integrity and genuine skill development.

4. Conclusion

Findings suggest that curriculum models are needed to embed Generative AI tools into pre-service teacher education. Pedagogical approaches that scaffold the critical use of Generative AI can significantly influence students' digital efficacy. Additionally, designing reflective assessment tasks assisted in teacher preparation and supports authentic classroom practice for the future.

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GROWING SKILLS AND INCLUSION WITH A HYDROPONIC ORCHARD

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Abstract

The participation of individuals with intellectual disabilities in higher education has traditionally been limited. However, this situation is gradually evolving due to the growing number of university programmes designed to foster their educational and social inclusion. At the University of A Coruña, the initiative "Espazo Compartido" offers an educational pathway focused on developing personal, social, digital, and pre-employment skills essential for autonomy and employability. Within this context, the use of horticultural activities is proposed as an active pedagogical resource, given its proven effectiveness in enhancing mental health, promoting social inclusion, and stimulating cognitive functions through plant cultivation and participation in structured activities. This proposal has been implemented in the TICARE project (Application of High Technology in Centers for the Care of Individuals with Intellectual Disabilities), which aims to innovate therapeutic and educational interventions through the integration of technology in the Centers for the Care of Individuals with Disabilities (CAPD) in Galicia. The HATHOR subproject (inaugurated in April 2025 at the CAPD in Coruña) consists of an indoor therapeutic orchard based on a closed hydroponic system, automated through home automation technologies, sensor networks, and remote control. The system is designed in accordance with universal accessibility principles and incorporates an interface adapted to the specific needs of individuals with intellectual disabilities, following established recommendations. It enables users to perform tasks such as watering, fertilizing, or activating the cooling system in a simple, intuitive, and safe manner—both on-site and remotely. In addition, the system supports continuous monitoring of the orchard's condition, tracking crop development, and automatic logging of horticultural activities and incidents. All this allows the garden to be semi-automated and for students to acquire basic digital skills. Manual tasks, such as pruning or harvesting, are carried out with the help of therapists and in compliance with accessibility and safety protocols. The resulting educational experience integrates experiential learning, assistive technologies, and engagement with the natural environment, enhancing psychosocial well-being, active social participation, and transitions towards autonomous and meaningful adult lives.

Keywords: *Digital skills, horticultural therapy, intellectual disabilities, orchard.*

1. Introduction

Although Article 24 of the Convention on the Rights of Persons with Disabilities explicitly recognizes the right to education at all levels, the participation of individuals with intellectual disabilities in higher education has historically been very limited in Spain. This situation has begun to change progressively with the emergence of university programmes specifically designed to promote their educational and social inclusion. A pioneering initiative in this field was the PROMENTOR programme, launched in 2004 by the Autonomous University of Madrid, which was subsequently followed by similar initiatives at other Spanish universities. Specifically, the University of A Coruña developed Espazo Compartido, a training programme aimed at individuals with intellectual disabilities and focused on the development of key competences for personal autonomy and employability.

These programmes share a competence-based approach that prioritizes the strengthening of adaptive, social, and digital skills, which are widely regarded as essential for the transition to a more autonomous and socially engaged adult life. Consequently, there is a growing need to identify active learning activities to be included in these programmes that allow these core competences to be addressed in a meaningful, accessible, and motivating manner.

In recent years, horticultural activities have become increasingly established as an effective educational and therapeutic resource in this context. Inclusive, therapeutic, or social orchards are commonly integrated into intervention and training programmes for individuals with intellectual disabilities or situations of dependency, with the aim of fostering personal autonomy, responsibility in task management, and social participation through cooperative work dynamics (Son, Kim and Park, 2022). Despite differences in terminology, these initiatives share a common understanding of the orchard as a structured environment for experiential learning.

In Spain, the National Centre for Environmental Education (CENEAM) has documented and disseminated numerous experiences related to inclusive community orchards, emphasizing accessibility and participation as fundamental design principles (Fundación Iniciativas Sur, 2025). More recently, projects such as the CiBiS/UAL Inclusive Orchard, promoted by the University of Almería (CiBiS/UAL, 2025), have framed horticultural practice within the context of so-called ecological therapies, conceived as a complement or alternative to conventional psychological interventions. Empirical evidence associated with these approaches highlights benefits in terms of social interaction, physical activity, contact with nature, and improvements in psychological well-being.

These outcomes are further supported by theoretical frameworks such as Attention Restoration Theory and Stress Recovery Theory, which argue that exposure to natural environments contributes to the restoration of cognitive resources and the reduction of stress. From this perspective, orchards—even when implemented in urban or indoor settings—can be considered valuable tools for promoting mental health and quality of life, particularly in populations with specific neuropsychological needs.

On this basis, the integration of orchard-based activities into structured training pathways emerges as an effective strategy for reinforcing autonomy, decision-making, and responsible participation in cooperative work processes. This paper presents HATHOR (Hydroponic Automated THerapeutic ORchard), as a proposal aimed at combining experiential learning, accessible technology, and the development of basic digital skills in individuals with intellectual disabilities.

2. HATHOR

2.1. Background

Hydroponics was chosen as a learning environment for two main reasons. First, for students with diverse disabilities, a solution was needed that was safe, and indoor-friendly. A closed-loop hydroponic configuration eliminates the intended users' need to utilize pesticides and heavy tools, functioning indoors within a classroom setting. Second, participants often lack agricultural experience and are involved in multiple competing tasks at the same time, so that, to ensure success, the system requires high autonomy and minimal manual maintenance. To achieve this, the developed closed-loop system automatically recirculates the nutrient solution, that is continuously reused, and precisely and automatically regulates pH, electrical conductivity (EC), salinity, and temperature to compensate for plant uptake. As discussed in (Ramón-Moreno, 2023) and (Gordo-Ruiz, 2017), this level of operational demand makes remote (telematic) monitoring a core requirement to ensure the system remains usable and stable for both students and staff.

2.2. Definition

HATHOR is a hydroponic and automated therapeutic orchard developed within the framework of the TICARE project (Application of High Technology in Centers for the Care of Individuals with Intellectual Disabilities in Galicia (CCIID); https://ticare.citic.udc.es/).

HATHOR was launched in April 2025 at the CCIID in A Coruña and, although it was deployed as a pilot project, it aims to stablish a scalable model for future seamless replication throughout the regional government's network of centers.

HATHOR allows students at the CCIID to experience the complete cultivation life cycle. They can monitor the full growth cycle and perform routine care (e.g., watering, fertilization, and temperature adjustment) via intuitive digital control, an experience that offers students significant multisensory stimulation. Also, the system is internet-enabled, so that students have real-time remote access enabling them to check crop status and exercise their responsibilities anytime and anywhere. Only physical agronomic tasks (e.g., pruning and harvesting) are conducted under therapist guidance to ensure safety and accessibility.

HATHOR is equipped with a network of sensors and actuators that facilitate semi-automated management, paired with two custom apps. The first schedules and records maintenance activities, while the second provides students with a control panel with intuitive controls for tasks such as irrigation, nutrient supply, and activation of the cooling system.

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2.3. Architecture

As shown in Figure 1, HATHOR defines an indoor learning space that utilizes a Nutrient Film Technique (NFT) configuration. The system is housed within a modular support structure engineered to minimize its physical footprint. The frame's design allows for front and lateral access, optimizing ergonomics for maintenance, supervision, and assisted agronomic tasks.

Figure 1. The orchard.

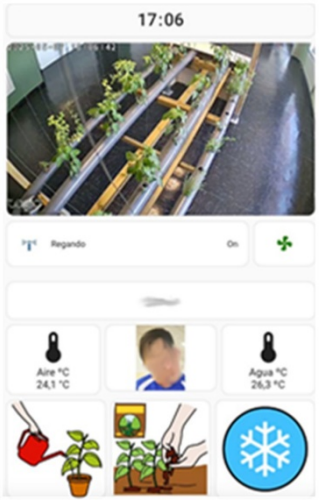
It has also been conceived as high-tech hydroponic therapeutic orchard, so that NFT is combined with advanced sensor monitoring, home-automation tools, and remote connectivity features. Specifically, it incorporates a distributed network of sensors and actuators based on SONOFF devices (ITEAD Intelligent Systems Co., 2025) and powered by a Raspberry Pi 5 running Home Assistant (Nabu Casa Inc., 2025). This architecture enables real-time, WiFi-based data acquisition for both hydroponic and environmental variables, while allowing mechanical components to be managed as individual addressable entities within Home Assistant. Consequently, the platform facilitates complex conditional automations, scripted routines, and contextual mobile alerts.

2.4. Automated behavior

The system uses Home Assistant to coordinate sensors and actuators, enabling smart behaviors like self-adjusting lights, timed nutrient dosing, and adaptive cooling systems of water and air. It also oversees user activity and provides a dedicated "maintenance mode" for technical interventions. To ensure these features are accessible to everyone involved, two specialized applications were developed: the Administration App for management and Therapeutic App for participant interaction, shown respectively in Figures 2 and 3.

Figure 2. Administration App.

Figure 3. Therapeutic App.



Designed specifically for staff, the Administration App serves as a unified hub for overseeing the orchard's health and operation. Staff can inspect live sensor data and visualize historical trends for pH, EC, and salinity to support long-term crop care. Beyond environmental monitoring, the app centralizes lighting and shutter control, live camera feeds, and the management of nutrient-solution cycles. It also includes a "maintenance mode" for technical interventions and specific corrective actions with configurable timers. To prevent accidental misconfiguration, users with disabilities do not have access to this app.

The Therapeutic App is designed specifically for tablet use, offering a user-friendly interface for students to interact with the orchard under supervision. It provides a simplified overview of the orchard's status, focusing on key indicators such as air and water temperature. It allows users to perform only three specific tasks: irrigation, fertilizer injection, and cooling activation. This limited number of options contributes to maintaining students' focus of attention. Each interaction is logged with timestamps and duration data, providing therapists with objective metrics to evaluate student engagement and refine future therapeutic interventions.

3. Results

During six weeks, and under the direct supervision of occupational therapists, eight participants with diverse intellectual disabilities participated in scheduled sessions to manage the orchard via the Therapeutic App, whose interface was specifically designed for cognitive and motor accessibility. They performed guided operations such as irrigation, nutrient injection, and climate control reaching the orchard the expected phenological stages (see Fig. 4).

Figure 4. Crops in HATHOR.

Therapists observed measurable gains in digital skills and greater independence in following routines, as well as in task-related autonomy, and visuomotor coordination. These findings were also supported by the data registered in the system's automated interaction logs, that facilitated the quantitative assessment of user activity, revealing specific participation patterns and individual developmental trajectories.

The validation of the installation was also successful, since all automated routines performed without failure or service interruptions. A key highlight was the robustness of the Raspberry Pi 5 core, which utilized local processing to ensure continuous operation during temporary connectivity losses. The overall stability, reliability, and operational efficiency of the platform is demonstrated by successful crop development.

4. Conclusions and future work

HATHOR is a high-tech, indoor hydroponic orchard designed for accessibility. Grounded in universal design, its semi-automated features enable students with intellectual disabilities to manage crop cycles while building real-world digital competencies thanks to the use of intuitive remote interfaces specifically adapted to users with intellectual disabilities. By combining experiential learning with assistive technology, HATHOR promotes psychosocial well-being and prepares students for autonomous lives and employability, as the validation results demonstrate that participants gain in issues such as digital skills and task-related autonomy. It ultimately makes orchards like HATHOR a valuable pedagogical tool to be incorporated in educational programmes dedicated to the social, educational and labor inclusion of persons with disabilities. At present, many universities implement programs dedicated to the social and educational inclusion of these persons, shifting the trend of the limited participation of individuals with disabilities in higher education, especially in the case of intellectual disabilities. At the University of A Coruña, the Espazo Compartido initiative provides a training pathway focused on personal, digital, and pre-employment competencies essential for autonomy. Therefore, future efforts will be dedicated to the systematic integration of HATHOR into the Espazo Compartido programme, as well as into other similar frameworks. It will also allow therapists to perform rigorous clinical evaluation of HATHOR's therapeutic impact.

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AN EXPERIMENTAL STUDY OF THE MECHANICAL ENGINEERING KNOWLEDGE OF CHATGPT AND GEMINI IN HIGHER EDUCATION

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Abstract

This paper presents an experimental study benchmarking the mechanical engineering (ME) knowledge of advanced Large Language Models (LLMs), specifically ChatGPT 5o and Gemini 3.0, within the context of higher education. Utilizing a methodical seven-stage comprehension framework, this study evaluates the models' abilities to process skills ranging from basic dimensioning to complex spatial reasoning and mechanical design processes. The results indicate that while both models excel at reproducing standardized knowledge – scoring 80% (Gemini) and 78% (ChatGPT) overall – they exhibit significant limitations in spatial awareness and the interpretation of complex technical drawings. Specifically, both LLMs failed in tasks requiring the generation of projections and the estimation of dimensions for detailed manufacturing drawings. The study concludes that while LLMs are powerful tools for general ME inquiries, their tendency to act as "skilled deceivers" by presenting incorrect technical data as valid solutions necessitates that students still need strong foundational expertise to verify AI-generated content.

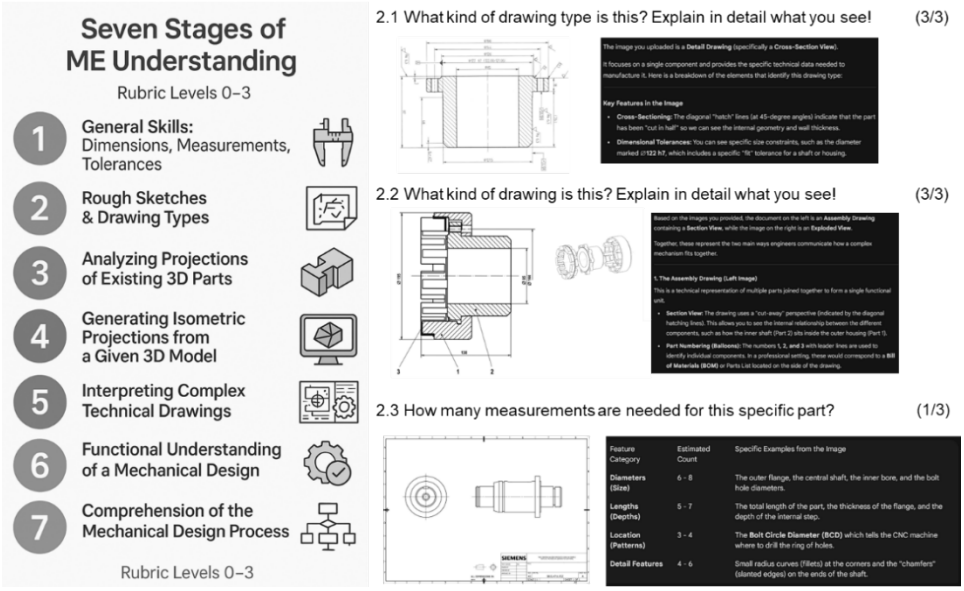
Keywords: *Mechanical engineering, LLM, engineering, benchmarking, engineering education.*

1. Introduction and testing methodology

Since the introduction of AI and the corresponding Large Language Models (LLMs) in 2022, students as well as researchers are exploring their limits and expanding their applications (Wang et al. 2025). The current models seem capable of developing an extensive understanding of the mechanical engineering (ME) domain (Yavartanoo et al. 2025). They seem to be able to analyze and understand complex technical drawings in 2D as well as simple 3D models (Wendland 2025). This recent development led to the idea of methodically testing their abilities and finding out which limits currently exist. Due to their current performance (Nelson et al. 2023), ChatGPT 5o and Gemini 3.0 were selected.

To thoroughly test the capabilities of a LLM, a methodical testing framework is developed, including seven stages (see figure 1, left side). All technical drawings can be found in Kurz et al. 2014.

Figure 1. Seven Stage Comprehension Model (left) and exemplary answers of stage 2 (right side), (drawings Kurz et al. 2014).



Each stage is designed to represent a different skillset and comprehension level, similar to what is expected from undergraduate students. The prompt responses are evaluated in four levels on a fixed rubric, ranging from 0 = no knowledge; 1 = basic knowledge of 1st/2nd semester students with some mistakes; 2 = advanced knowledge with minor mistakes; 3 = expert knowledge with no mistakes. These criteria allow a final comparison of the state of readiness for application in the ME domain. Exemplary questions and test materials of stage 2 are shown on the right side of figure 1. For each stage, the framework questions will be discussed in detail and a summary of the LLMs ability will be given.

2. Testing framework: Seven stages of ME comprehension

Starting with the **first stage**, general skills like applying basic dimensions and analyzing measurements as well as checking mechanical tolerances are tested. The test questions are weighted equally and are worth 3 points each, the results are displayed in parenthesis (points achieved/maximum points available):

1.1 How many drawing types are there in general in mechanical engineering? (3/3)
1.2 Why does the design often start with a rough sketch instead of a drawing? (3/3)
1.3 How many dimensions are necessary to fully describe this design? (L-bracket) (3/3)
1.4 How many different types of tolerances are there for dimensions? (3/3)

The results: all drawing types (1.1) are correctly mentioned, e.g., a detail drawing for manufacturing, an exploding view drawing for assembly and an assembly drawing for the overall view of all components installed. Next, the answer why a design often starts with a sketch in engineering (1.2) is answered adequately, e.g. “in engineering and industrial design, starting with a rough sketch instead of a formal technical drawing is a deliberate strategy. While a technical drawing is meant to tell the truth (precision), a sketch is meant to explore a possibility (ideation)”. Moving on to a more complex question (1.3), an L-bracket is presented in an isometric perspective and the LLM is tasked to assess how many dimensions are needed to fully represent the design. Both models answer correctly by stating five necessary dimensions (height, length, width, vertical leg thickness and horizontal base thickness). Finally, the knowledge about tolerance for dimensions is tested (1.4). Both LLMs score maximum points by listing three tolerance types, e.g., size tolerances, geometric tolerances and fits + allowances. Stage 1 is successfully completed by both LLMs and shows that the questions type just query existing standard knowledge – something that modern LLMs excel at, thus both score 12/12 points.

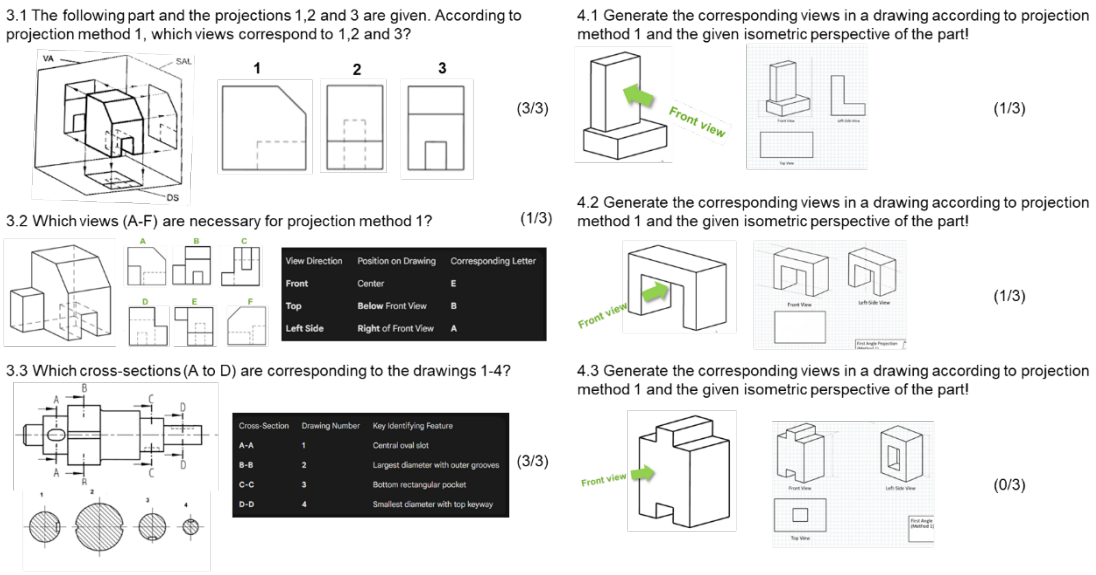
Next up, the **second stage** focuses more on the interpretation of drawings and requires a deeper skillset. The three corresponding questions and their images are shown in figure 1 (right side), and reveal interesting results:

2.1 What kind of drawing type is this? Explain in detail what you see! (3/3)
2.2 What kind of drawing type is this? Explain in detail what you see! (3/3)
2.3 How many dimensions are needed for this specific part? (1/3)

In the first test, a cross-sectional view of a single component is uploaded (2.1), acting as a detail drawing for manufacturing. Both LLMs correctly identify it as such, and Gemini interprets the information from the drawing mostly correctly by stating the dimensions and tolerances depicted in the drawing. This means that current LLMs can read and understand images and extract as well as interpret information from simple detail drawings. Following this, a different type of drawing in the form of an assembly drawing is uploaded (2.2). The differences to the detail drawing are explained correctly and the ideas of the exploding view (showing the spatial relationship) and the assembly drawing (section views with assembly dimensions, orientation and part numbering for the bill of materials) are referenced. To increase the difficulty, a very complex manufacturing drawing is presented, which usually requires students 2-3 hours to complete. The LLMs are asked how many dimensions/measurements are thought to be needed. Here, their inadequate ability to process more detailed images step-by-step and apply/link their existing knowledge becomes apparent. Both LLMs fail and greatly underestimate the number of dimensions (ChatGPT: 20-22 / Gemini: 18-22; Solution: 35+ dimensions). It becomes obvious that the LLMs try to score with very general information instead of concise details related to the uploaded image, a method that seems very humanlike. Gemini scores 7/9, ChatGPT 6/9 points.

The **third and fourth stage** analyze the ability to read, understand and create projections from given 3D images. To distinguish between the skillsets, the third stage gives only quizzes (3.1-3.3, figure 2, left side), which require the LLM to recognize and sort the views according to a given projection method, while the fourth stage demands creating these projections (figure 2, right side).

Figure 2. Stage 3 (left side) and Stage 4 (right side) of projection quizzes (drawings Kurz et al. 2014).



While the first question (3.1) is answered correctly, the more complex situation and choices of the second question (3.2) seem to disrupt both LLMs, resulting in low scores. The last question of stage 3 involves assigning given cross-sections to the corresponding drawings (3.3), and the LLMs both have no problem in solving the task correctly. Next, complexity is increased by switching from analyzing to creating projections in stage 4. **This stage produced by far the weakest results from both LLMs**. Although the given part designs were geometrically simple, they were not able generate the correct corresponding views for projection method 1 and failed in all three questions (see figure 2, right side). One hypothesis to explain this behavior is that the LLMs need to switch to their image generation module, and while text analysis and generation is excellent in current models, there seems to be a loss of information, especially regarding the spatial arrangement (tested in January 2026 with Nano Banana for Gemini 3.0 and DALL-E for ChatGPT 5o). Stage 3 quizzes were completed by the LLMs with 7/9 points, while stage 4 only awarded 2/9 points. It becomes apparent that spatial awareness and spatial arrangement is a missing skill in current LLMs.

Stage 5 and 6 ask to interpret technical drawings, a skill where most students seem to have difficulty at first. The questions get progressively more complex (see figure 3):

5.1 Interpret this drawing! What mechanical part do you see? (3/3)
5.2 Interpret this manufacturing drawing? What kind of part is shown here? (3/3)
5.3 What is show in this assembly drawing? (1/3)
6.1 Which parts do you see in this mechanical drawing? (3/3)
6.2 Which mechanical parts are shown in this exploded view? (3/3)
6.3 Which mechanical design element is shown here and what is its purpose? (3/3)

Results of **stage 5** indicate that simple mechanical parts and detail drawings can be easily understood by the LLMs, with regards to their dimensions (5.1) and their corresponding function (5.2). Once more parts are added and a complex assembly drawing with shafts, gears and keys is introduced, the interpretations get inaccurate and lead to guessing. One possible reason could be that the missing spatial awareness is hindering the LLMS in making the right conclusions. Stage 5 resulted in 7/9 points for both LLMs.

In contrast to this, **stage 6** showed their full potential by scoring the maximum 9/9 points. For question 6.1, both LLMs correctly identify the shaft, the hub/housing and a feather key which connects both parts. Since this is a commonly used connection method in mechanical engineering, the widespread information in textbooks and other sources allow the LLMs to successfully interpret this drawing. Next, an exploding view of multiple parts joint together is presented (6.2). Again, the information given is accurate and results in full scores. The last question shows a double direction thrust ball bearing (6.3), which is designed to support axial loads from two directions. Both LLMs correctly identify it as such and therefore the overall stage 6 score results in 9/9 points.

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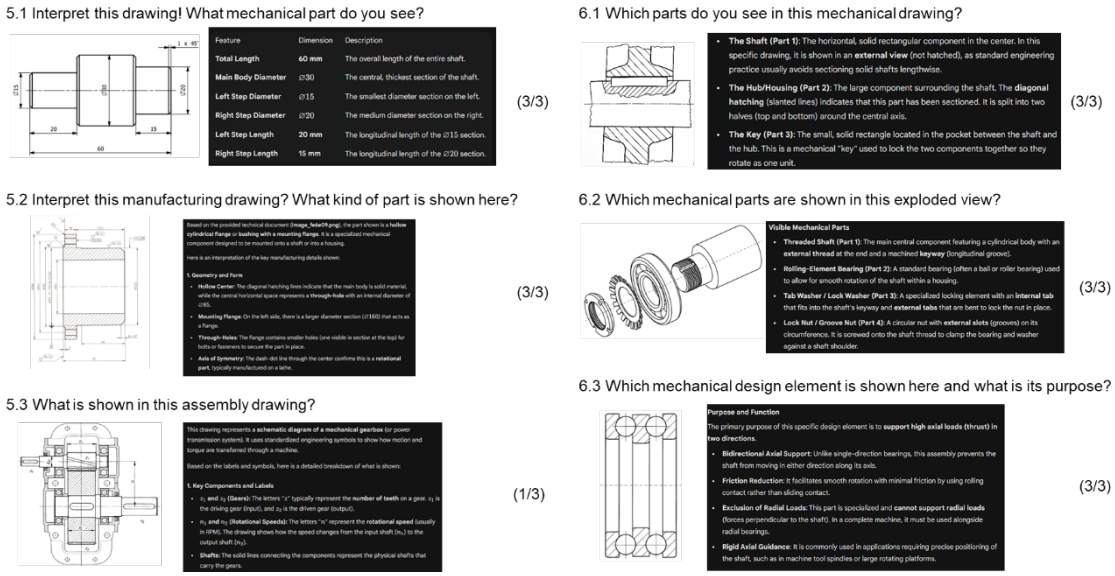
Figure 3. Stage 5 (left side) and Stage 6 (right side) for drawing knowledge (drawings Kurz et al. 2014).



The last **stage 7** tests the comprehension of the mechanical design process with three questions:

7.1 What are major steps in a mechanical design process? List all steps and give examples!
7.2 Which methods do you recommend ensuring a successful planning phase? And what is the main difficulty in the planning phase?
7.3 Which product is described in this functional structure plan?

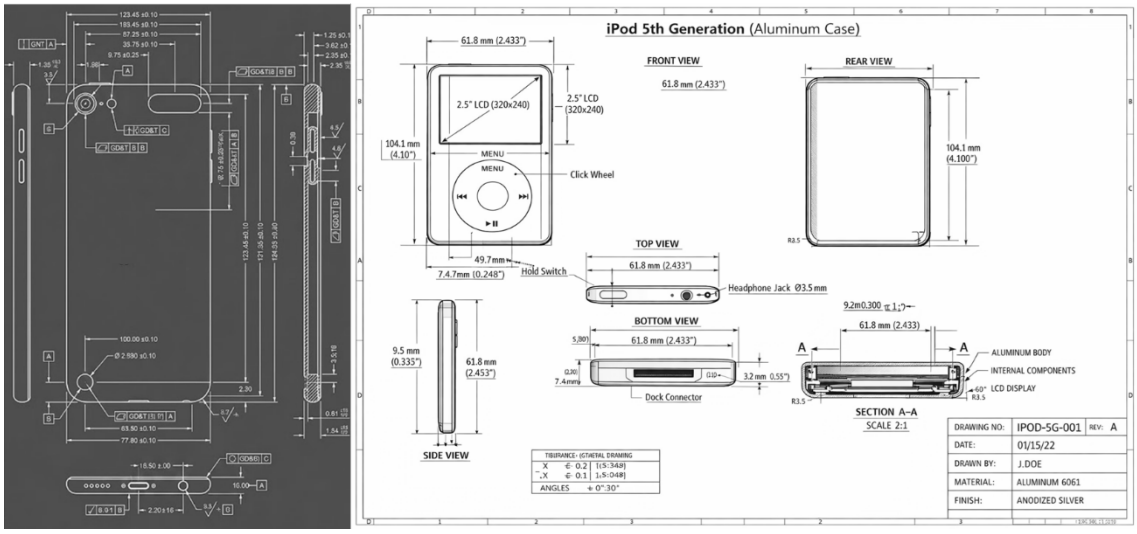
As expected, no problems arise for the LLMs due to their foundational knowledge of mechanical engineering and design processes: they offer the right steps (7.1 – from problem definition via specification to concept design, prototyping, testing and final documentation), the fitting methods (7.2 – Quality Function Deployment, Requirement specifications, Design Failure Mode and Effects Analysis, etc.) and more interestingly, they also list the main difficulties while designing (7.2 - Low Info vs. Cost Paradox, Scope Creep and Discipline Silos). Even when prompted with an unknown functional structure (7.3), both LLMs correctly identified the shown product as a Drip Coffee Maker. This shows a very broad ability to interpret and provide information in context of a mechanical design process. Therefore, the final result for stage 7 is 9/9 points.

3. Summary and discussion

Both LLMs score evenly across the 7-stage testing framework and achieve 53/66 points (Gemini, =80%) or a close 52/66 points (ChatGPT, =78%). **In general, the more precise a design question or task is, the better the results of a LLM are**. The more knowledge in form of texts, graphs, images, textbooks, blogs, forums is available, the better they reproduce this existing knowledge. **This means that common ME problems, machine elements and other standardized design challenges are well within the capability realm of modern LLMs.** If it has been discussed somewhere before, the LLMs will most likely present potential solutions.

On the other hand, the less information is available for a certain ME item, the more the LLM diverts from the available data points and the more vague the results become**. Challenged to understand and interpret complex assembly and manufacturing drawings, both LLMs failed**, but presented their wrong answers as true. **This is the "dark side" in current LLMs, they seem to act by design under the concept of the "skilled deceiver".** Being excellent at presenting made-up information as valid solutions, they appear to offer good knowledge at first glance. It is that often only with appropriate expert knowledge that the user can notice the incoherences. This poses the biggest problems for students, because in complex design situations, the given LLM solutions often conceive the novice users, while being unusable in reality.

Figure 4. Results of Gemini (left) and ChatGPT (right) for the prompt: "Create a mechanical manufacturing drawing for an iPod 5. Gen with all the necessary dimensions, include multiple projection".



One example of this can be seen in figure 4, where Gemini and ChatGPT were asked to produce a manufacturing drawing for an iPod Gen. 5 case made of aluminum. It becomes obvious that the LLMs try to score with very general information instead of concise details related to the complex question or an uploaded image. **The results shown reflect in no way a feasible manufacturing drawing and would result in a complete fail in an exam.** Furthermore, once spatial awareness or arrangement is necessary to solve a task, current LLMs fail completely. One hypothesis of the author that could explain this behavior is that the LLMs need to switch to their image generation module, and while text generation is excellent in current models, there seems to be a loss of information, especially regarding the spatial arrangement (tested in January 2026 with Nano Banana for Gemini 3.0 and DALL-E for ChatGPT 5o**). So, whenever spatial reasoning is required, the current LLMs do not generate adequate results and have to be used with utmost care.**

As with regards to **teaching in Higher Education**, it becomes apparent that one major skill for the students must be to be able to verify the results of LLMs when using them. This is even more applicable when faced with complex ME design situations, but fact-checking is only possible with a minimum of design knowledge and know-by-heart expertise about the ground-truths of engineering: materials, manufacturing, design rules. Although the impressive performance of both Gemini and ChatGPT in this testing framework indicate that they will play a large role in modern teaching and ME, the **students must still learn the basic skillsets and ground truths before applying AI**. A common question, which arises at this point is "how to motivate the students to still learn the basic knowledge?", even though that part is easily covered by LLMs. The uncomfortable answer might be that it is the only way to decipher the "Skilled Deceivers" in the future.

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THE MODEL OF DIGITAL TRANSFORMATION OF HIGHER EDUCATION INSTITUTIONS

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Abstract

Digital technologies are now deeply embedded in both personal and professional lives, prompting institutions to pursue digital transformation (DT). This process extends beyond technological advancement to encompass the reconfiguration of organisational structures, processes, and cultures. Successful DT depends on key foundations such as visionary leadership, strategic planning, effective resource allocation, adequate investment, and a culture that fosters innovation, adaptability, and continuous learning. In higher education, digital transformation is often linked to pedagogical innovation. However, administrative, managerial, and support processes are equally important, as they underpin improvements in educational quality, research performance, and overall institutional effectiveness. As public-sector organisations, universities also face additional pressures related to technological modernisation, regulatory requirements, and organisational restructuring. This study explores the main challenges, opportunities, and strategies that enable digital transformation in higher education, drawing on evidence from four European universities. A theoretical model of DT in higher education is proposed and empirically assessed through qualitative content analysis of institutional digital strategies and semi-structured interviews with university representatives involved in digital transformation initiatives. This approach offers an in-depth understanding of institutional strategies and practices. The findings show that digital transformation in higher education is a multidimensional process, not merely a technological undertaking, involving significant organisational, cultural, and competency-related changes. Effective transformation requires strategic foresight, systemic coordination, and sustained institutional commitment. The results also indicate that a clear digital strategy and active leadership are decisive drivers of digital transformation, while organisational culture, human resource capabilities, and management systems play significant supporting roles.

Keywords: *Digital transformation, higher education, model, institutions, interviews.*

1. Introduction

Digital transformation represents a continuation and deepening of informatization, which refers to the introduction of information technologies into work and social systems to improve efficiency, productivity, and communication (Masuda, 1980). Digital transformation, however, focuses not only on technological upgrades but also on transforming business models, organisational structures, and socio-economic systems in the digital age. It requires the comprehensive integration of digital technologies, such as cloud services, big data, the Internet of Things (IoT), and artificial intelligence (AI), into all aspects of business and social life (Pucihar et al., 2021). This process occurs in both the private and public sectors.

Digital transformation in public sector organisations is complex and multistage, requiring the effective addressing of key challenges such as ensuring data security and privacy, bridging the digital divide, and developing digital skills among public employees and service users. It is also essential to secure stable and long-term funding for digital transformation projects, as short-term approaches often do not enable sustainable solutions. Furthermore, aligning digital transformation with existing legislative and regulatory frameworks can slow the introduction of innovations. Promoting a digital culture within the organisation and overcoming resistance to change among public employees and service users, who may be reluctant to adopt new ways of working, is also crucial. Finally, it is important to ensure that digital services remain accessible to all, including vulnerable groups often marginalised in digital processes. Kitsios et al. (2023) emphasise the importance of change management strategies and continuous training to ensure that the public sector not only keeps up with technological trends but also leverages them effectively to improve public services and democratic processes.

Although higher education institutions, especially in Europe, are considered public institutions providing public services, their digital transformation is based on the same foundations. As described by Kitsios et al. (2023), the best way to achieve successful digital transformation, and thus improve the quality of education, research, and organisational processes, is through the development and implementation of a comprehensive socio-organisational environment for transformation. To this end, our research focuses on developing a comprehensive model of digital transformation for higher education institutions, based on modern theoretical approaches and adapted to the specific needs of these institutions. We set the following research question: What are the key components of the comprehensive digital transformation of higher education institutions?

2. Background

As digital transformation sets new standards in the business environment, it is important to recognise that its success is neither self-evident nor guaranteed. Comprehensive digital transformation depends on solid foundations, including thoughtful and visionary leadership, strategic planning, and the effective use of available resources.

Governance plays a central and decisive role in digital transformation. The foundation of successful digital transformation is a vision from leadership that clearly defines the goals and expectations of the transformation and provides the necessary commitment to overcome the associated challenges. This commitment must be evident at all levels of the organisation, as without a unified vision for digital transformation, it cannot be successfully implemented. Setting the direction and priorities of digital transformation projects is another key aspect (Al Nuaimi et al., 2022; Müller et al., 2024).

Strategic planning with effective project management is the second key element of successful digital transformation. It begins with clearly defined goals and priorities that guide the transformation and ensure that all resources are focused on shared objectives. This step requires a deep understanding of business processes and digital solutions that address the needs of the modern work environment and promote innovation and competitiveness within the organisation. In addition, effective resource management and time planning are essential to ensure that projects are set realistically and implemented in line with expectations and constraints. This involves optimising the use of financial, human, and technological resources and continuously adapting plans in response to changing circumstances and findings during implementation (Al Nuaimi et al., 2022; Pucihar et al., 2021).

The third prerequisite for digital transformation is ensuring sufficient capital. This includes not only financing direct technology investments, such as new information and communication equipment, software, and digital platforms, but also a broader understanding of the cost and benefit implications of digital transformation. Management must assess how investments affect an institution's operational efficiency, market positioning, and long-term financial stability. The key is long-term financial planning, which involves establishing stable budgets to support current and future projects, managing investment-related risks, and ensuring that digital transformation contributes to the organisation’s sustainable development (Lafioune et al., 2023; Müller et al., 2024).

At the heart of digital transformation is a workforce whose role extends beyond technical expertise and requires a culture focused on innovation and continuous learning (Opland et al., 2022). Hiring staff with digital skills is essential to bring fresh ideas and approaches that can drive transformation. It is equally important to invest in existing employees to expand their digital skills and encourage adaptability. Creating an environment that fosters continuous learning and experimentation is vital for maintaining organisational dynamism. Strengthening such a culture requires commitment at all levels, from management to individual team members, and highlights the importance of soft skills alongside technical knowledge (Chen et al., 2024).

A strong technological infrastructure, supported by reliable data security and regulatory compliance, is essential for successful digital transformation. Advanced technological infrastructure enables organisations to leverage new technologies to improve efficiency and innovation. Data security and regulatory compliance are fundamental safeguards against cyber threats and ensure data confidentiality. It is also necessary to regularly assess and upgrade technological systems to ensure they are prepared to meet future technological challenges and needs. This process requires a strategic approach to information technology management, focusing on long-term performance and security (Garcia-Perez et al., 2023; Gebremeskel et al., 2023).

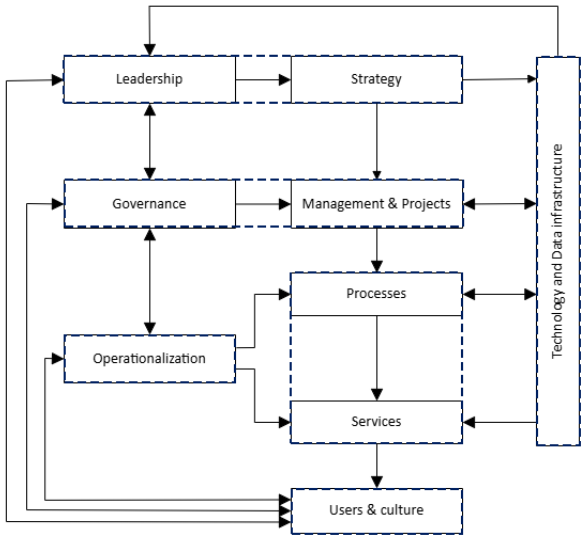
3. The proposed model

The model was developed using four existing digital preservation models: two primarily oriented towards the private sector and two towards the public sector. McKinsey's 7-S model is a theoretical

framework for implementing changes based on a company's organisational design and is not necessarily focused on digital transformation. The model emphasises that mutual influences occur when one of the elements is transformed, requiring an effective balance to be re-established among all the elements (Liu, 2020). It illustrates the relationship between hard elements (strategy, structure, and systems), which represent the formal framework of digital transformation by defining the goals, processes, and technological solutions that enable operational implementation of changes, and soft elements (shared values, leadership style, staff, and competencies), which form the core of organisational transformation by influencing the acceptance of change, ways of working, and the long-term success of digital initiatives (Kimberling, 2023). The PricewaterhouseCoopers (PwC) model covers six key areas: strategy, corporate culture and human capital, development of a digital transformation plan, construction of a digital business platform and operating model, implementation and operational development, and performance review, helping companies transform their business models, operations, and culture (Cozmiuc & Pettinger, 2021). The model proposed by Mergel et al. (2019) provides a comprehensive framework for understanding and implementing digital transformation in the public sector, covering not only technological upgrades but also changes in organisational culture, processes, policies, and citizen relations (Mergel et al., 2019). The model presented by Vial (2019) emphasises the role of digital technologies as sources of disruption, prompting strategic responses through the use of digital technologies to discover new ways of creating value by adapting organisational structures and culture, as well as management and employees, while considering ethics and social implications.

Based on the analysis of these four models, we created a model of digital transformation for higher education institutions, which is a multidimensional and ongoing process requiring simultaneous changes in strategy, organisational management, human resources (people and culture), technological infrastructure, and processes. The proposed model, with six components, emphasises that none of these components should be considered in isolation. The synergy between the components allows each to reinforce the others: leadership and governance establish strategic direction and organisational structures, which are operationalised through management, projects, processes, and services. These directly influence users and organisational culture and generate feedback and data for further strategic and governance-related decisions. Technology and data infrastructure act as a cross-cutting support area, enabling the implementation of all the aforementioned activities.

Figure 1. Suggested model.



4. Empirical research

4.1. Methodology

The model was empirically validated using qualitative research through semi-structured interviews, which provided in-depth insights into the perceptions, experiences, and decision-making practices of key actors in the digital transformation of higher education institutions. The interviews were conducted either in person or remotely (online), depending on the availability and consent of the interviewees. Where interviewees consented, the conversations were audio-recorded and subsequently transcribed. When recording was not permitted, responses were obtained in written form. The interviewees were the Vice-Rector for Digitalisation and Knowledge Transfer from the University of Ljubljana,

Slovenia; a representative of the rectorate from the Technical University Graz, Austria; the Chief Digitalisation Officer from the University of Bern, Switzerland; and the Vice-Rector for Digitalisation from the University of Vienna, Austria. The analysis was based on a predetermined analytical framework derived from the developed model of digital transformation in higher education, which enabled a systematic comparison of the empirical findings with the theoretical assumptions. Furthermore, we analysed the digital transformation strategies of the universities mentioned above and paired them with the interview transcripts.

4.2. Results

A comparative analysis of all semi-structured interviews confirms a high degree of consistency between the developed model and findings from practice. In all cases, it is consistently evident that digital transformation has been systematically supported by a clearly defined digital strategy and the active role of senior management. The University of Bern and Graz University of Technology are particularly consistent examples where strategy and leadership are not only declarative but also operationalized through formally adopted guidelines, dedicated resources, and a clear vision. The University of Vienna also confirms the model's emphasis on a strategic framework linked to investment planning and central steering. The University of Ljubljana further confirms the model, while at the same time providing an empirical example of a key model warning: when management coordination is not established early enough and decisively enough, digital initiatives are scattered into partial solutions at the member level, which directly confirms the model's thesis about the risks of ad hoc digitization.

The interviews also confirm that the model correctly identifies governance, people, and culture as conditions without which technology cannot create lasting value. All institutions need formalized coordination mechanisms that transcend organizational silos. All interviewees confirmed that the human factor is both a systemic constraint and a key accelerator: resistance to change, differences in digital competencies, and a lack of digital talent are present in all cases, but institutions differ in the maturity of their response. TU Graz has demonstrated an upgrade of the model at the level of implementation mechanisms with a special remuneration model, while UL has highlighted the limitations of the public sector in competitive recruitment. The common denominator is clear: competencies, communication, training, stakeholder involvement, and a culture of trust are a central part of transformation management.

The most decisive proof of the model's validity is the recurring finding that the effects of digital transformation only materialize through the redesign of processes and services, with technological solutions being merely an enabling factor. In all cases, the interviews describe standardization, integration, and process redesign, confirming the model's interdependence of components: without resources, there is no technology; without process redesign, there are no benefits; without a culture of change, there is no acceptance; and without management, silos arise. The deviations that occur are not conceptual inconsistencies, but implementation constraints (time, human resources, financial capacity, autonomy of members), which do not contradict the model, but empirically reinforce it. On this basis, we can conclude that the results of the interviews not only confirm the model, but also operationalize it with good practices that show how its components are actually implemented in real higher education environments.

5. Conclusion

The results of the study confirm that a clear digital strategy and active management play a key role in the level of digital transformation in higher education institutions, while organisational culture, human resource factors, and management systems are also important.

The digital transformation of higher education institutions requires overcoming numerous challenges, such as a lack of digital skills among employees, resistance to change, data security and privacy issues, and limited financial resources for sustainable solutions. The key success factors in implementing these changes are appropriate leadership, planning, financing, and human resource management, as these factors directly influence an organisation’s readiness for innovation, collaboration, and adaptability in the digital transformation process.

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INSTITUTIONAL EXPERIENCE OF THE UERJ PRÓ-SUS NETWORK: A MODEL OF ACADEMIC COLLABORATION AND PUBLIC HEALTH INNOVATION

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Abstract

The UERJ Pró-SUS Network is an institutional initiative coordinated by the Health Vice-Rectorate of the State University of Rio de Janeiro aimed at strengthening the Brazilian Unified Health System (SUS) through the integration of teaching, research, extension, and technological innovation. Designed as a collaborative and interdisciplinary platform, the network connects researchers, students, health professionals, and public managers to address concrete challenges faced by public health services. By 2025, the digital platform of the network had mapped approximately 200 academic projects related to the SUS and involved 39 academic and administrative units of the university, including research institutes and university health services. During the same period, 19 new interdisciplinary projects were structured to respond to strategic priorities such as health promotion in vulnerable territories, transgender health, environmental sustainability and health, digital health innovation, and care strategies for individuals with Autism Spectrum Disorder. The initiative illustrates how collaborative academic networks can strengthen health systems by translating scientific knowledge into applied solutions. The experience reinforces the role of universities as key actors in promoting equitable and sustainable public health policies.

Keywords: *Public health, SUS, health innovation, academic-service integration, interdisciplinary networks.*

1. Introduction

The Brazilian context adds additional layers of complexity to the organization and financing of public health policies. The country has an estimated population of more than 213 million inhabitants distributed across a territory of approximately 8.5 million km², placing it among the five largest countries in the world in terms of geographical extension (IBGE, 2024). This territorial scale translates into profound regional inequalities and significant sociocultural diversity, marked by the coexistence of distinct urban and rural realities, traditional communities, Indigenous territories, and large metropolitan areas. Such territorial multiplicity directly influences health care practices, requiring public policies to consider epidemiological, cultural, and socioeconomic differences among regions and communities.

In this context, the Brazilian Unified Health System (Sistema Único de Saúde – SUS) plays a central role in guaranteeing universal access to health care, providing services to approximately 72% of the Brazilian population—around 164 million people—who depend exclusively on the public system for medical care (IBGE; International Trade Administration, 2024). From a financing perspective, Brazil allocates approximately 9.7% of its Gross Domestic Product to health expenditures, representing hundreds of billions of reais invested annually in the sector and reflecting the magnitude of the effort required to sustain a universal health system in a country of continental dimensions (IBGE, 2024; OECD, 2025).

In this scenario, the combination of vast territorial extension, sociocultural diversity, and high demand for public health services underscores the importance of institutional strategies capable of integrating scientific knowledge, technological innovation, and public management, reinforcing the role of universities in developing solutions to the challenges faced by the SUS.

Universities are increasingly recognized as key actors in strengthening health systems through scientific research, professional training, and technological innovation. International literature highlights the importance of academic–service collaboration in improving health system performance and accelerating the translation of research into practice (Frenk et al., 2010; WHO, 2020). In this context, collaborative academic networks have emerged as strategic mechanisms for connecting universities with health systems and public policy development.

In response to this challenge, the State University of Rio de Janeiro (UERJ) created the UERJ Pró-SUS Network, an institutional initiative designed to connect academic research and innovation with the concrete demands of the public health system. The network promotes interdisciplinary collaboration among researchers, students, and health professionals to develop solutions capable of improving public health services.

2. Design / Objectives

The UERJ Pró-SUS Network was designed as an institutional collaborative platform oriented toward strengthening the Brazilian Unified Health System. Its central objective is to mobilize academic knowledge and technological innovation to develop solutions capable of improving the quality, accessibility, and efficiency of public health services.

More specifically, the initiative seeks to integrate teaching, research, extension, and innovation activities across multiple academic units of the university. By promoting interdisciplinary collaboration, the network encourages researchers from fields such as medicine, engineering, public health, social sciences, and information technology to work together on applied research projects related to public health challenges.

The network also aims to strengthen partnerships between the university and health services linked to the SUS, creating an environment in which knowledge production and practical application occur simultaneously and contribute to improving health system performance.

3. Methods

The implementation of the UERJ Pró-SUS Network followed a structured methodological approach based on the mapping of academic competencies, the organization of interdisciplinary collaboration, and the development of applied research projects.

Initially, a mapping process identified research groups, laboratories, and academic initiatives within the university with potential relevance to the SUS. Researchers were invited to register their projects on a digital platform designed to facilitate communication, visibility, and collaboration among participants.

Based on this mapping, thematic working groups were created around priority areas related to public health challenges. These groups develop interdisciplinary projects aligned with real demands from health services. Periodic meetings and workshops promote knowledge exchange, methodological alignment, and evaluation of project progress.

Monitoring mechanisms and impact indicators were also established to assess the scientific, institutional, and social outcomes of the network's activities.

4. Results

The creation of the UERJ Pró-SUS Network produced significant institutional and academic results. The initiative currently integrates 39 academic and administrative units of the university, including faculties, research institutes, and university health services such as the Hospital Universitário Pedro Ernesto and the Policlínica Piquet Carneiro.

Through its digital platform, the network has mapped approximately 200 academic projects related to the SUS, covering areas such as health promotion, environmental health, digital health technologies, health management innovation, and strategies focused on vulnerable populations.

During 2025, the network supported the development of 19 new interdisciplinary projects aimed at strengthening the SUS. These initiatives addressed strategic themes including: health promotion in vulnerable territories; transgender health; sustainability and the environment–health interface; digital health innovation; care strategies for individuals with Autism Spectrum.

The projects combined academic research with service-based collaboration, promoting territorial engagement and knowledge exchange between researchers and health professionals.

Figure 1. Institutional Indicators of the UERJ Pró-SUS Network.

Indicator	Value
Academic and administrative units involved	39
Projects mapped on the platform	~200
New interdisciplinary projects structured in 2025	19
Main thematic areas	Health promotion, digital health, environmental health, equity
Institutional coordination	Health Vice-Rectorate – UERJ

5. Discussion

The experience of the UERJ Pró-SUS Network highlights the importance of collaborative academic networks in addressing complex public health challenges. Public health problems are inherently multidimensional and require interdisciplinary approaches capable of integrating technological, social, and organizational perspectives.

The network can also be understood within the broader framework of health innovation ecosystems, in which universities, health services, governments, and communities interact to produce knowledge and technological solutions. Institutional environments that facilitate collaboration and co-production of knowledge is essential for transforming academic research into socially relevant innovation.

By connecting academic expertise with the concrete demands of health services, the network contributes to reducing the gap between knowledge production and practical application in public health systems. This model reinforces the strategic role of universities as drivers of social innovation and public policy development.

6. Conclusions

The UERJ Pró-SUS Network represents an innovative institutional model for strengthening collaboration between universities and public health systems. By integrating interdisciplinary research, technological innovation, and direct engagement with health services, the initiative contributes to improving the organization, management, and quality of health care within the Brazilian Unified Health System (SUS).

Since its implementation, the network has demonstrated a significant capacity to mobilize academic knowledge and institutional resources in favor of public health. Currently, the initiative integrates **39 academic and administrative units of the State University of Rio de Janeiro**, including faculties, research institutes, and university health services. This broad institutional participation reflects the interdisciplinary nature of the network and its potential to connect diverse fields of knowledge in the development of solutions for complex health challenges.

Through its digital platform, the network has already mapped **approximately 200 academic projects with direct relevance to the SUS**, covering areas such as health promotion, digital health technologies, environmental health, health management innovation, and strategies aimed at vulnerable populations. In addition to the mapping of existing initiatives, the network actively stimulated the creation of **19 new interdisciplinary projects throughout 2025**, focused on strategic public health priorities including health promotion in vulnerable territories, transgender health, sustainability and the interface between environment and health, technological innovation, and care strategies for individuals with Autism Spectrum Disorder.

The digital platform created to support the network has also played an important role in expanding the visibility and accessibility of academic initiatives related to public health. Since its implementation, the platform has registered **more than 3k views**, reflecting growing institutional and public interest in the articulation between university research and the needs of the public health system.

Beyond quantitative indicators, the initiative has generated important qualitative impacts. The network has strengthened interdisciplinary collaboration within the university, expanded opportunities for student training and professional development in real health system contexts, and increased the visibility of applied research with direct relevance to public policies.

In this sense, the UERJ Pró-SUS Network illustrates how universities can function as **institutional hubs for innovation in public health**, capable of connecting scientific knowledge, technological development, and social needs. The experience reinforces the strategic role of higher education institutions in contributing to the sustainability and continuous improvement of universal health systems, particularly in countries marked by territorial diversity and social inequalities such as Brazil.

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WALLET-BASED MICRO-CREDENTIALS IN IMMERSIVE EDUCATION: EUROPEAN GOVERNANCE FOR PRIVACY-PRESERVING VERIFICATION

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Abstract

As European education increasingly experiments with immersive, metaverse-like environments, the portability of learning outcomes across institutions and platforms becomes a practical requirement. In parallel, European policy developments promote micro-credentials and the wider adoption of machine-verifiable attestations, increasingly conceived as wallet-presented verifiable credentials. This trajectory is reinforced by Regulation (EU) 2024/1183, which establishes the European Digital Identity Framework and provides the legal basis for European Digital Identity Wallets. Within immersive learning contexts—where learners may move across multiple platforms, institutions, and communities—credentialing becomes an infrastructure of trust, but also a potential source of privacy risks, particularly through linkability, metadata leakage, identity persistence, and excessive logging. This paper argues that the central governance challenge is not merely issuing digital credentials for immersive learning, but ensuring that credential ecosystems do not evolve into cross-context tracking infrastructures. To address this challenge, the paper develops a technical-legal governance model for privacy-preserving, interoperable educational credentials in the European context. The model combines a lifecycle-based risk taxonomy, privacy-preserving presentation patterns, and institutional governance levers for procurement and policy. It is then applied to a cross-institution European scenario in which immersive course completion is attested through wallet-presented credentials and verified by external institutions or employers. The paper concludes with a blueprint for privacy-preserving credentialing that supports trustworthy recognition of immersive learning outcomes while safeguarding learner privacy, agency, and fairness.

Keywords: *Verifiable credentials, digital identity wallets, data protection, governance, educational metaverse.*

1. Introduction

Immersive and metaverse-like learning environments are increasingly discussed as part of the evolving digital infrastructure of higher education. Their appeal lies in the possibility of supporting distributed participation, simulation-based learning, persistent collaborative spaces, and more flexible forms of learner mobility across institutional and platform boundaries. In such environments, however, portability of learning outcomes becomes more than an administrative convenience: it becomes a condition for the practical recognition of educational achievement beyond the platform in which learning originally occurred. At the same time, scholarship on micro-credentials in higher education has emphasized their growing relevance as modular, transferable, and complementary forms of recognition within broader lifelong learning ecosystems (Ha et al., 2022).

The European policy context gives this question particular urgency. The Council Recommendation on a European approach to micro-credentials promotes common understanding, recognition, and comparability of micro-credentials across learning and employment settings (Council of the European Union, 2022). In parallel, Regulation (EU) 2024/1183 amended the eIDAS framework to establish the European Digital Identity Framework, including European Digital Identity Wallets (European Parliament and Council of the European Union, 2024). The European digital credential ecosystem, as also reflected in Europass, increasingly presents educational credentials as portable, verifiable, and learner-centred instruments for documenting diplomas, certificates, and micro-credentials (Europass, n.d.).

Against this background, this paper argues that wallet-based micro-credentials in immersive education should not be assessed solely in terms of interoperability and trust. They must also be examined as governance infrastructures that shape how personal data circulate across contexts. The crucial issue is that a credential system designed to facilitate recognition may also create new possibilities for correlation, profiling, and identity persistence across institutions, platforms, and verifiers. The aim of the paper is therefore threefold: to analyse how verifiable credential ecosystems can support recognition of learning in immersive environments; to identify the privacy and governance risks associated with issuance, presentation, verification, revocation, and logging; and to propose an institutionally actionable blueprint for privacy-preserving verification in the emerging European wallet ecosystem.

2. Wallet-based credentials in immersive education

Micro-credentials are especially relevant in immersive education because learning in metaverse-like environments is often modular, platform-mediated, and distributed across multiple actors. A learner may complete a virtual laboratory, participate in an avatar-based simulation, or develop skills in a cross-institution immersive course that does not map neatly onto conventional transcript structures. In such settings, machine-verifiable credentials offer a potentially attractive means of documenting specific learning outcomes in a portable and reusable format. That portability, however, only becomes meaningful if other institutions, employers, or platforms can verify the credential in a trustworthy and interoperable way. This is one reason why wallet-based presentation is becoming increasingly important in the European debate (Council of the European Union, 2022; Europass, n.d.).

From a technical and governance perspective, verifiable credential ecosystems are usually described in terms of issuers, holders, verifiers, wallets, and registries. Recent scholarship on self-sovereign identity and digital wallets emphasizes that these ecosystems promise greater user control, data minimisation, and modular trust relationships, but also depend on organizational choices about standards, privacy-enhancing technologies, and role allocation (Babel et al., 2025). In education, the attraction of wallet-based credentials lies precisely in the possibility of moving from institution-centric records toward learner-mediated presentation. Yet this shift does not automatically guarantee privacy. If wallet interactions generate excessive metadata, if verifiers request more attributes than necessary, or if revocation and logging practices are poorly designed, the learner may become more observable across contexts rather than less (Babel et al., 2025).

For immersive education, the stakes are even higher. Metaverse-like learning environments already generate rich behavioural and contextual data, and credentials derived from those environments may implicitly reflect highly granular forms of participation. As a result, credential portability cannot be understood as a purely functional question. It must also be understood as a question of data protection, governance, and educational fairness. This is precisely the problem identified in the abstract, which frames wallet-mediated credentialing as both an infrastructure of trust and a possible vector of linkability, metadata leakage, and identity persistence.

3. Risks and governance challenges across the credential lifecycle

A useful way to analyse these issues is to examine the credential lifecycle. At the issuance stage, institutions must decide what exactly is being attested, how learning outcomes are described, and what identifiers or metadata are embedded in the credential. Even where the attested achievement is legitimate and useful, over-specification may create privacy risks by revealing more about the learner than is needed for later verification. At the storage stage, the governance question concerns where credentials are kept, what the wallet provider can observe, and whether the technical design preserves holder control. At the presentation and verification stages, the central risks concern over-disclosure, linkability, verifier overreach, and the generation of persistent metadata trails. Revocation and auditability introduce further tensions: institutions may require ways to manage invalid credentials, but revocation mechanisms and verification logs can also create additional observability if they are not carefully designed (Flamini et al., 2024; Ramić et al., 2024).

The literature on selective disclosure is especially important here. Recent reviews describe selective disclosure as a core privacy feature of digital credentials, allowing holders to reveal only the attributes necessary for a given transaction rather than exposing the entire credential (Ramić et al., 2024). Cryptographic research also shows that different selective disclosure mechanisms involve trade-offs concerning unlinkability, standard maturity, performance, and support for more advanced proof structures (Flamini et al., 2024). For educational micro-credentials, this means that privacy-preserving verification cannot remain an abstract aspiration: it must be translated into concrete design choices about attribute minimisation, proof mechanisms, verifier requests, and revocation models (Flamini et al., 2024; Ramić et al., 2024).

There is also a governance issue of role allocation. In educational settings, the issuer may be a university, consortium, or training provider; the holder is the learner; the verifier may be another institution, employer, or platform; and the wallet may be provided within a broader EU digital identity ecosystem. Each actor potentially influences the purposes and means of processing. Consequently, privacy-preserving credentialing requires more than good cryptography. It requires institutional rules on who may request which attributes, how long verification logs may be retained, whether secondary use is permitted, and how learners can contest errors, refusals, or inappropriate verification demands.

4. A technical-legal governance model

This paper proposes a technical-legal governance model for metaverse-ready educational credentials structured around three components.

The first is a lifecycle-based risk taxonomy. This taxonomy maps risks across issuance, storage, presentation, verification, revocation, and logging, while distinguishing the governance roles of issuer, holder, verifier, and wallet provider. The purpose is to make visible where privacy risks are likely to emerge and which actor is in the best position to mitigate them. This element corresponds to the lifecycle-based risk taxonomy explicitly described in the abstract.

The second component consists of privacy-preserving presentation patterns. These patterns are grounded in data minimisation, selective disclosure, and purpose limitation. In practice, this means designing credential requests around necessity rather than convenience: a verifier should request only the minimum claims required for the specific educational or employment purpose at stake. Where possible, credential presentation should reduce the exposure of stable identifiers, limit reusable metadata, and avoid creating correlation points between different transactions. This aligns both with the privacy-oriented rationale behind the EU wallet ecosystem and with the technical literature on selective disclosure in digital credentials (European Parliament and Council of the European Union, 2024; Flamini et al., 2024; Ramić et al., 2024).

The third component consists of institutional governance levers. These include procurement requirements, contractual limitations on secondary use, retention rules for logs and verification records, internal policies on role allocation, and procedural safeguards linked to fairness, accessibility, and contestability. In other words, the privacy quality of a credential ecosystem depends not only on protocol design but also on institutional governance choices. A wallet-based system can only be privacy-preserving in practice if the surrounding educational organisation prevents function creep and over-verification. This institutional dimension is also expressly anticipated in the abstract, which highlights procurement, retention, fairness, accessibility, and contestability as core governance levers.

5. Scenario-based application

To illustrate the model, consider a cross-institution European case in which a learner completes an immersive course delivered in a metaverse-like environment. The course provider issues a micro-credential attesting successful completion and specific learning outcomes. The learner stores the credential in a wallet and later presents it to another university for recognition or to an employer as evidence of competence. In a simple interoperability narrative, this appears to be an ideal use case: portable, machine-verifiable recognition of immersive learning. Yet from a governance perspective, the scenario quickly becomes more complex.

The first question concerns what the credential actually contains. A privacy-preserving design would avoid embedding unnecessary contextual details about the immersive platform, persistent learner identifiers, or excessive course metadata. The second question concerns presentation: must the learner reveal the full credential, or only selected attributes relevant to the decision at hand? The third concerns verification and logging: can the verifier confirm validity without creating a durable transaction history that later enables cross-context correlation? Finally, revocation and auditability must be handled in ways that preserve trust without undermining learner privacy. The scenario therefore stress-tests precisely the tension

identified in the abstract: the challenge is not only to issue credentials, but to prevent the credential ecosystem from becoming a distributed tracking infrastructure.

6. Conclusions

Wallet-based micro-credentials offer a promising route for recognising immersive learning outcomes across institutional and platform boundaries in Europe. They fit well with the European push toward portable, machine-verifiable attestations and with the emerging architecture of EU digital identity wallets (Council of the European Union, 2022; European Parliament and Council of the European Union, 2024; Europass, n.d.). Yet their value depends on more than technical interoperability. Without privacy-preserving presentation, restrained logging, and clear institutional governance, educational credentialing can become a mechanism for cross-context visibility rather than learner empowerment (Babel et al., 2025; Flamini et al., 2024; Ramić et al., 2024).

For this reason, trustworthy credentialing in immersive education should be built around three principles: minimum necessary disclosure, bounded observability, and accountable institutional governance. A European approach that combines verifiable credentials with wallet-based control can support recognition, portability, and trust, but only if it resists the temptation to treat verification as an unlimited data extraction opportunity. The ultimate governance question is therefore not whether immersive learning can be credentialed digitally, but how such credentialing can preserve learner privacy, agency, and fairness while remaining interoperable and credible across contexts.

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CHALLENGES AND DEVELOPMENT OPPORTUNITIES OF GLOBAL TEAM LEARNING PROJECTS

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Abstract

Drawing on a thematic analysis of post-project self-reflection feedback from X-Culture participants, the paper highlights crucial lessons learned, performance disparities, and actionable recommendations to improve pedagogical design, thereby enhancing cross-cultural cooperation readiness in global online team learning. Learners in the global action learning project teams that had culturally diverse membership developed reports for enterprises interested in choosing and entering new export markets. In their post-project written reflections, students stressed several competencies for successful action learning in global online team settings. The most frequently mentioned competencies included mastering effective cross-cultural communication, adapting to diverse styles and expectations, and developing time management and scheduling skills across multiple time zones. Other vital takeaways include effective teamwork and collaboration, the emergence of informal leadership in virtual teams, and the need for adaptability when dealing with technical constraints. The paper highlights the pedagogic challenges of applying self-managing online project teams.

Keywords: *Action learning, cross-cultural learning, social skills, online teams.*

1. Introduction

Earlier discourse at END conferences has focused on the shift toward online and hybrid education models, with university-level online team projects emerging as a crucial means of fostering collaboration and developing 21st-century skills in engineering studies (Yeang et al., 2025). However, business students are even more in need of international online team collaboration to understand export markets. Implementation of digital learning communities promotes collaborative learning and peer mentorship (Adhikari et al., 2025). Students who study international business can develop their social and cross-cultural competencies, combined with knowledge of potential export markets, through global online learning communities such as X-culture (https://x-culture.org/). Participation in X-Culture global project teams requires cross-cultural learning and readiness for online project work. It may mean, for some students, leaving their comfort zone to engage, for the first time, in online action learning with team members they have not met before and cannot choose. In X-Culture, teams are created based on the diversity of nations within each team. International organizers appoint no team leaders, and teams must exercise a high degree of self-management when choosing an enterprise challenge for their project work, selecting a new export market, and preparing an action plan to enter this foreign market. That raises the research question: What are the learning outcomes and challenges in X-Culture projects for Estonian business students? This research aims to enhance cross-cultural cooperation readiness for global online team projects, with a view to future employment and entrepreneurship opportunities for students from a small open economy.

2. Conceptual foundations

Collaborative learning focuses on knowledge co-creation (Vuopala et al., 2019). Combining digital and intercultural competencies in digital teamwork is an essential learning need for success in the changing World (Maak, 2020). Online project teams are characterised by geographical distance between members, a common purpose, asynchronous and/or synchronous online communication tools, and knowledge-sharing practices, negotiated social structures, interdependence, and opportunities to bring together team members from different organisations (Charteris, Berman & Page, 2021). The effectiveness of diverse workgroups in face-to-face settings has been extensively studied for many years (Stahl et al., 2021). Still, less research has focused on multinational teamwork in an online environment. Research findings have been conflicting:

some researchers have found a positive relationship between diversity and team performance, while others have found a negative correlation (Han & Beyerlein, 2016). Developing students' critical and reflective thinking skills has become essential in recent years for preparing learners to make better decisions using artificial intelligence tools (Bell & Bell, 2023). In projects to assist enterprises in entering export markets, AI tools should be used in combination with insider information from those markets. Educators at business schools should support learners by applying culturally inclusive educational technologies (Akinrinola et al., 2020), and projects in global, diverse online teams are one way to use these technologies to understand different cultures and foster further international cooperation. Inclusive learning must take into account the digital divide, as students in developing countries often have unequal access to digital technology and skills (Peña Estrada et al., 2025).

The global X-Culture consortium has, since 2010, involved 110,000 learners in 20,000 global teams from 70 countries (Taras, 2025). X-Culture organisers allocate students to virtual online teams, ensuring each team reflects geographical and cultural diversity. Students must agree within their team on the international business opportunity challenge they choose to solve together, working online for 2.5 months. Students must pass the pre-test to demonstrate their knowledge of online communication, knowledge-sharing tools, and X-Culture rules. Online team projects focus on international market expansion strategies, which typically involve conducting comparative market research, analyzing international competitors, developing marketing campaigns, recruiting personnel, managing logistics, and other essential aspects of international business growth. Creativity in X-Culture is needed to identify new global business opportunities, align students' knowledge-sharing styles across cultures, and find the best online collaboration tools, including social media applications, when team members never meet in person during their project work. X-Culture team reports are graded by lecturers representing all universities where team members study.

3. Research design

Our earlier research on X-Culture teams that used data from X-Culture international data involving 2992 business students working in 596 virtual teams demonstrated that teams which have more task conflicts during their first weeks of teamwork when they have to conduct industry analysis and choose concepts for assessing the international competitiveness of the project enterprise and tools for comparing foreign markets present at the end of their project better reports than teams, where team members do not recognise and address such conflicts (Elenurm & Fabritius, 2023).

Our present research is based on the feedback from 230 post-project reflective reports of Estonian Business School students who participated in X-Culture global teams as the main assignment of their international business course. Students shared their challenges and lessons learned, along with suggestions for improving online collaborative learning environments. Thematic analysis of their self-reflections was conducted. The thematic analysis results were compared with the average project report grades that teams in which students were involved received from graders representing the universities of their team members.

4. Results

The thematic analysis findings are presented in two tables: Lessons learnt from the online teamwork experience; Comparison between high-achieving and average or below-average students' reflections.

Table 1 highlights the ten most frequently mentioned lessons learnt that students identified as key takeaways from their participation in international online teamwork projects. These lessons involve skills in cross-cultural communication, time management, collaboration, leadership, and adaptability. The number of mentions indicates how many students addressed each theme in their written reflections. The highest number of students stressed effective cross-cultural communication as their main lesson learnt. In their post-project reflections, they linked cultural differences to different communication styles, including rational reasoning and emotional responses, when discussing project tasks and the division of labour via online communication channels. Time zone differences were pointed out, especially when communicating with students in the USA and South America. Skills for building trust without face-to-face meetings were identified as a lesson learnt, especially for teamwork and project collaboration, especially for sharing project work responsibilities. Several students stated that their lesson learnt was how to emerge as an informal leader and motivate other team members for project work. Some students stated that the lack of leadership was the main challenge in their global online teamwork. Technical constraints of using IT tools were mainly related to team members from developing countries.

Table 1. Frequent lessons learnt from global project work based on post-project self-reflection reports.

Lesson Learnt	Explanation	Mentions
Effective Cross-Cultural Communication	Understanding and adapting to different communication styles, languages, and cultural expectations in international teams.	30
Time Management and Scheduling	Managing project tasks and meetings effectively across multiple time zones with varying availability.	28
Teamwork and Collaboration	Working effectively in diverse teams, often without face-to-face meetings, by building trust and sharing responsibilities.	26
Leadership in Virtual Teams	Emergence of informal leadership roles to coordinate tasks, motivate members, and ensure project completion.	24
Adaptability and Flexibility	Adjusting to unexpected challenges, differing work habits, and technical constraints.	22
Conflict Resolution and Diplomacy	Resolving disputes and managing disagreements constructively to maintain team harmony.	21
Use of Digital Collaboration Tools	Using tools like WhatsApp, Google Docs, Zoom, and Doodle to coordinate and share work.	20
Responsibility and Accountability	Taking ownership of assigned tasks and ensuring reliability within a distributed team.	18
Importance of Early Planning	Starting early and setting clear goals and timelines to reduce last-minute stress and miscommunication.	17
Value of Diverse Perspectives	Appreciating how different backgrounds contribute to richer discussions and better problem-solving.	15

Table 2 highlights differences in post-project reflections between students in teams that received above-average project grades and those in other teams.

Table 2. Reflections of above-average grade compared to average/below-average grade students.

Difference Area	Above Average Students	Average/Below Students
Leadership Emergence	Proactively assumed leadership roles and delegated tasks clearly.	Less initiative in leadership; often lacked clear role distribution.
Communication Practices	Used multiple channels (WhatsApp, Zoom, Google Docs); emphasized clarity and frequency.	Often faced delays or miscommunication due to irregular updates and limited tools.
Handling of Conflicts and Free Riding	Confronted issues early, redistributed tasks, or corrected teammates' work.	Frequently tolerated passive members; conflicts were often left unresolved.
Commitment and Motivation	Expressed strong commitment; went beyond assigned roles to ensure quality.	Motivation varied; some noted low engagement due to external workloads or disinterest.
Reflection Depth and Learning Attitude	Provided in-depth self-reflection and strategic learning outcomes.	Reflections were more descriptive than analytical, focusing primarily on challenges with the report format.

Comparative analysis of student reflections revealed significant differences between students with above-average project report grades and those with average/below-average grades. High-performing students proactively assumed leadership roles, utilized multiple communication channels (e.g., WhatsApp, Zoom, but also some project management tools), and consistently confronted free-riding or conflicts early.

In contrast, lower performers often tolerated passive team dynamics, experienced delays due to irregular communication, and provided more descriptive than analytical post-project reflections. Low-performing team members tended to reflect more on technical or procedural barriers (e.g., tool unfamiliarity, miscommunication). In contrast, high-performing team members reflected more strategically (e.g., on group norms, role clarity, and feedback mechanisms). Students in low-performing teams also often complained that their team members could not devote enough time to X-Culture as they had competing learning assignments. Group discussions based on post-project reports revealed that many students, in their daily lives, often prefer messaging apps that assume real-time chat and rapid, short responses. Such a habit creates tension among team members in different time zones. Students should be more ready to use project management tools and understand the role of asynchronous communication when discussing report sections, where pre-reading and critical thinking are essential. Relying on synchronous communication tools diminishes focus on analysis and can lead to personal conflicts resulting from rapid emotional responses to other team members.

To maximize the potential for skills development in projects, students proposed practical improvements to instructional design. The top recommendations prioritize structural clarity and support, emphasizing the need for more explicit initial instructions and for facilitating early team-building activities. Some students suggested that instructors should assign online team leaders and prescribe online communication tools for use during the project work.

5. Discussion

In line with studies such as Mason et al. (2025), the post-project reflections revealed that cultural diversity functioned as a double-edged sword when participants had to open their cultural or academic "silos". Students reported both lessons learnt and challenges. Those in higher-performing teams highlighted how diversity contributed to creativity and broader perspectives on internationalization strategy. In contrast, others struggled more with conflicting expectations, language barriers, and discomfort with addressing conflicts stemming from ambiguity in team leadership and differing preferences for online communication tools. Our results partly support the conclusions of Taras (2025) about the importance of informal communication and competing project commitments as online global project work challenges. However, in the Estonian context, time zone differences and differences in online communication habits regarding synchronous messaging preferences were also seen as challenges, especially when communicating with students in the USA and South American countries.

Some students suggested that instructors should assign international team leaders to enhance coordination and prescribe unified communication platforms to reduce misunderstandings and improve team alignment in online environments. However, implementing such suggestions would diminish opportunities to learn self-regulation in global online teams.

6. Conclusions

In the era of new online communication tools and artificial intelligence applications, educators face the challenge of increasing students' readiness for action-learning processes in which learners must leave their comfort zones and exercise team autonomy in online, cross-cultural project work collaboration, communication, and critical thinking. The key lessons learnt for best performers were self-organizational skills and greater intercultural awareness, particularly regarding differences in work styles, values, and communication norms. Readiness to adapt to the pre-knowledge and communication styles of team members from distant countries will help discover new international business and entrepreneurship opportunities in the changing geopolitical landscape. Such readiness is especially valuable for business students in small open economies. Educators can prepare students for online global projects by introducing them to best practices for self-managed team formation and project management tools to organize collaboration among team members representing different cultures and time zones before the project starts.

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CITIZEN SCIENCE AND CONNECTION WITH NATURE IN THE BIO-SOLAR PROJECT: ECOSOCIAL INVOLVEMENT IN RESEARCH ON BIODIVERSITY AND RENEWABLE ENERGY

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Abstract

The European project Bio_Solar proposes an innovative approach that combines science, education, and social participation to investigate the effects of solar parks on biodiversity and to promote sustainability in rural communities. Through citizen science programs developed in educational centers, the project fosters the involvement of students, teachers, and local residents in observing and recording flora and fauna species around photovoltaic installations. This active participation not only expands the scientific database on biodiversity but also strengthens the connection with nature, pro-environmental behaviors, and critical understanding of the energy transition. The work proposes the integration of digital tools and participatory methodologies (such as mobile applications and collaborative monitoring) that link formal learning with applied research, reinforcing the relationship between scientific knowledge and social action. Furthermore, the educational and social benefits of this co-designed and participatory intervention model are analyzed. Within the framework of Nature based Solutions (NBS), the Bio_Solar experience is presented as an opportunity to transform solar parks into spaces for active learning, intergenerational interaction, and environmental responsibility. The project demonstrates that education and citizen science are key tools to promote an inclusive and participatory ecological transition.

Keywords: *Citizen science, environmental education, renewable energy, biodiversity, connectedness to nature.*

1. Introduction

The energy transition and the accelerated loss of biodiversity constitute two of the most pressing socio-environmental challenges of the twenty-first century. In Europe, the expansion of renewable energies —particularly photovoltaic installations in intensively farmed agricultural landscapes— raises questions about their compatibility with biodiversity conservation and community well-being. Recent reports from IPBES (2024) and the IPCC (2023) warn that global biodiversity is declining at an unprecedented rate due to agricultural intensification, climate change, habitat fragmentation, and pollution, thereby compromising the ecosystem services essential for human life (Díaz et al., 2019). In this context, Nature-based Solutions (NbS) have emerged as a strategic framework for addressing ecological degradation while simultaneously supporting human needs (Cohen-Shacham, Walters, Janzen, & Maginnis, 2016). NbS emphasise the restoration, management, and enhancement of ecosystems to deliver multiple co-benefits, making them particularly relevant in transformed landscapes such as solar farms (Nesshöver et al., 2017). These infrastructures, often located in degraded or intensively cultivated areas, offer unique opportunities to reintroduce vegetation cover, improve soil quality, enhance habitat connectivity, and create refuges for flora and fauna (Lambert, Bischoff, Enea, & Gros, 2023). When appropriately designed and managed, solar farms can function not only as energy-producing facilities but also as ecological assets that contribute to climate mitigation, biodiversity recovery, and rural resilience (Ascensão, Chozas, Serrano, & Branquinho, 2023). Where increasing aridity and soil pressure intensify ecological vulnerability, integrating NbS into solar farm management becomes especially critical for reconciling energy production with conservation goals. Within this framework, the European Bio_Solar project, under the Nature-based Solutions call from *Biodiversa+,* proposes an innovative approach that combines ecological research, social participation, and environmental education to evaluate the potential of solar farms as multifunctional spaces capable of generating clean energy while simultaneously enhancing biodiversity and fostering social engagement in sustainability.

Alongside these ecological challenges, a parallel social concern has gained increasing relevance: the progressive disconnection of individuals from the natural world and, consequently, from contemporary environmental issues (Hughes, Richardson, & Lumber, 2018; Soga & Gaston, 2023). Research indicates that a combination of factors, including the early and sustained use of digital technologies, use of AI-generated images that distort real nature, accelerated urbanisation – which diminishing opportunities for contact with green spaces-, and, in rural contexts, social isolation and limited proximity to scientific and educational institutions, has contributed to a marked reduction in direct interactions with nature (Hughes et al., 2018; Guerrero-Casado, Murillo-Jiménez, Carpio, Tortosa, & Serrano-Rodríguez, 2025; Soga & Gaston, 2016). This trend, conceptualised as the "extinction of experience" (Pyle, 1978) has significant implications for human health, well-being, and the capacity to recognise, understand, and value local ecosystems. Within this scenario, the socio-educational dimension of the project becomes essential. Citizen science offers a promising avenue to re-establish meaningful human–nature relationships, enhance scientific, environmental, and biodiversity literacy, and foster more sustainable attitudes and behaviours.

In this sense, the Bio_Solar project seeks to bridge science and society by engaging citizens in real environmental challenges related to the energy transition and biodiversity conservation, guided by principles of equity and social justice. The programme is grounded in a participatory, structured, and accessible pedagogical framework designed to educate local communities about environmental issues and to support the transformation of perceptions, attitudes, and behaviours towards sustainability (Barrutia, Pedrera, Ortega-Lasuen, & Díez, 2024; Skarlatidou & Haklay, 2021).

2. Design of the proposal

The socio-educational component of Bio_Solar was designed as a structured, participatory programme integrating citizen science, experiential learning, and NbS principles. It addresses both biodiversity loss and the social challenges linked to nature disconnection through a multi-layered approach combining formal education, community engagement, and applied ecological research. The programme is organised around four pillars: a participatory pedagogical framework, integration of citizen-science tools, co-creation with local stakeholders, and alignment with social-ecological sustainability goals.

2.1. Participatory pedagogical framework

The intervention is grounded in a participatory and inquiry-based pedagogical model that positions learners and community members as active contributors to environmental research. The framework incorporates Universal Design for Learning (UDL) principles to ensure accessibility for diverse participants, including women farmers, elderly residents, and people with disabilities. Activities are designed to promote scientific literacy, critical thinking, and pro-environmental attitudes through direct engagement with local biodiversity and renewable-energy infrastructures.

2.2. Integration of citizen science tools and ecological monitoring

Digital tools commonly used in citizen-science initiatives (iNaturalist, PlantNet, Merlin) support species identification, georeferenced data collection, and collaborative validation. These are combined with ecological monitoring techniques such as transects, point counts, and camera-trap deployment, enabling participants to contribute to robust datasets while gaining hands-on experience.

2.3. Co-creation and community engagement

A central element of the programme is the co-creation of the educational and participatory activities with the school community and local stakeholders. Elementary and secondary school students, teachers, women farmers, local associations, and other community members collaborate in designing schedules, materials, and communication strategies for the biodiversity monitoring events. This participatory approach strengthens ownership, ensures that the intervention reflects local priorities, and promotes inclusive engagement across age groups and social sectors.

Students also develop promotional and communication campaigns to invite the broader community to participate, fostering intergenerational learning and reinforcing social cohesion. The programme follows a sequential structure that supports progressive engagement:

- Introductory training sessions on biodiversity, solar farm ecology, and digital tools.
- Collaborative design of the community sampling
- Integration of community feedback into the final design.
- Implementation and dissemination of results.

2.4. Social-ecological aspects and sustainability goals.

The design explicitly aligns with NbS principles by promoting ecological enhancement within a transformed landscape while simultaneously generating social benefits. By situating learning activities within a solar farm—an emblematic site of the energy transition—the programme fosters a deeper understanding of the interdependencies between biodiversity, renewable energy, and rural sustainability. The design also supports the development of community capacities to engage with environmental decision-making and contributes to a more socially just and ecologically grounded energy transition.

3. Objectives

The socio-ecological intervention developed within the Bio_Solar project pursues a set of interconnected scientific, educational, and social objectives. These objectives reflect the dual ambition of the programme: to generate robust ecological knowledge while strengthening community engagement, environmental literacy, and connection with nature.

3.1. Scientific objectives

- To document the biodiversity present in and around a Mediterranean solar farm through a combination of citizen-generated observations and expert ecological monitoring.
- To assess the potential of solar farms as multifunctional landscapes capable of supporting biodiversity under NbS principles.
- To compare citizen-science data with researcher-collected datasets to evaluate data quality, complementarity, and potential contributions to long-term ecological monitoring.
- To explore the relationships between land-use intensity around solar farms and biodiversity patterns in transformed rural landscapes.

3.2. Educational objectives

- To enhance scientific, environmental, and biodiversity literacy among stakeholders (secondary schools' community, university students, farmers, landowners, solar farms workers, local people and volunteers)
- To strengthen participants' connection with nature through direct, structured, and meaningful contact with local ecosystems.
- To develop participants' competencies in ecological observation, digital data collection, and critical interpretation of environmental information.
- To promote understanding of the energy transition and its ecological implications, fostering informed and critical perspectives on renewable-energy infrastructures.

3.3. Social objectives

- To foster inclusive community participation in environmental monitoring, with particular attention to women farmers, local associations, and vulnerable groups.
- To promote intergenerational learning and strengthen social cohesion in rural areas.
- To support equitable engagement in sustainability initiatives by applying participatory and accessible pedagogical approaches.
- To contribute to a socially just energy transition by integrating local knowledge, community values, and scientific evidence.

4. Methods and implementation

The methodological approach combines quantitative ecological monitoring with qualitative and participatory techniques, integrating citizen-science tools, experiential learning, and structured data-collection protocols. The methods are designed to ensure scientific rigour while maximising accessibility and community engagement ensuring inclusion.

4.1. Participants

The intervention involves a broad range of stakeholders from rural communities surrounding the solar farm. Participants include primary and secondary school students and teachers, university students and researchers, local farmers and landowners, Solar-farm workers and maintenance staff, elderly residents and local associations and volunteers from the wider community. This diverse composition ensures intergenerational learning, inclusion, and the integration of local ecological knowledge.

4.2. Training and preparatory sessions

Participants take part in a series of structured training sessions designed to build foundational knowledge and practical skills including introduction to local biodiversity, solar-farm ecology, training in the use of digital citizen-science tools (iNaturalist, PlantNet, Merlin), workshops on ecological monitoring techniques (transects, point counts, camera traps). Training is delivered through interactive demonstrations, hands-on practice, and collaborative exercises to ensure accessibility and inclusion.

4.3. Data collection procedures

Data collection was organised into two complementary field sessions. Firstly, researchers and university students accompanied the school community to the surroundings of the solar farm to learn and practise ecological sampling techniques (transects, point counts, vegetation surveys, camera traps) and to apply the use of citizen-science apps in real field conditions. The second session consisted of an open community bioblitz, involving all project stakeholders. During this event, school students acted as guides, teaching other participants how to use the apps and apply the sampling techniques learned previously, while researchers coordinated data validation and sampling zones. All records were uploaded to iNaturalist, combining structured monitoring with community-led data collection.

4.4. Evaluation of educational, social and scientific outcomes

The evaluation framework integrates scientific, educational and social indicators to capture the multidimensional impact. Scientific outcomes are assessed through the number and diversity of species recorded, the complementarity between citizen-science and researcher-generated datasets, and the quality of georeferenced observations. Educational outcomes are evaluated through short reflective pre- and post- questionnaires, field-notebook entries and observation of participants' engagement, focusing on gains in biodiversity literacy, scientific skills and connection with nature. Social outcomes are examined through participation levels, intergenerational collaboration and the inclusion of women farmers, elderly residents and other community groups. This mixed-method approach provides a comprehensive understanding of how the intervention influences ecological knowledge, learning processes and community involvement.

4.5. Data analysis

Ecological data collected are analysed using descriptive statistics and cross-validation to compare species richness, abundance and data quality across participant groups. Citizen-generated observations are contrasted with expert datasets to assess accuracy and complementarity. Qualitative materials — questionnaires, field notes and group discussions— are analysed through thematic coding to identify patterns related to learning, engagement and social cohesion.

4.6. Multi-country implementation and comparative design

Although implementation is currently taking place in Córdoba (Spain), the programme will be replicated in Sweden, Poland, and Spain to enable comparison across a north–central–south European gradient. Harmonised protocols will support cross-regional analysis of biodiversity patterns, citizen-science engagement, and the transferability of the pedagogical model, as well as the identification of region-specific opportunities and constraints for integrating Nature-Based Solutions into solar-farm management. This multi-country design strengthens the robustness of the findings and supports the development of generalisable insights into the ecological and social potential of solar farms across Europe.

5. Discussion

The ongoing implementation of the Bio_Solar programme provides early insights into how citizen science and participatory pedagogies can operate within renewable-energy landscapes. Initial observations suggest that combining ecological monitoring with experiential learning may help counteract the 'extinction of experience', as participants —especially students— engage more deeply with local biodiversity through direct observation, digital tools, and collaborative fieldwork.

Co-creation also appears to strengthen participants' sense of ownership and relevance, supporting findings that participatory approaches foster trust and long-term engagement in citizen-science initiatives. At the same time, the dual data-collection strategy raises methodological questions—such as data accuracy and variability—that will be examined as analyses progress, offering an opportunity to assess the complementarity of expert and citizen-generated datasets.

The forthcoming multi-country implementation will further illuminate how socio-ecological contexts shape participation, learning processes, and biodiversity patterns. Overall, these emerging observations highlight both the potential and the challenges of integrating citizen science into renewable-energy infrastructures, underscoring the need for continued data collection and refinement of the programme's methodological and educational components.

6. Conclusions

Although the Bio_Solar project is still underway, the initial phases indicate that integrating citizen science within a participatory and educational framework can effectively connect biodiversity monitoring with community engagement in the energy transition. Early implementation suggests that solar farms can function as spaces for learning and environmental awareness, strengthening participants' scientific literacy and connection with nature through hands-on ecological activities.

The involvement of diverse community groups—students, teachers, farmers, elderly residents, and volunteers—highlights the potential of citizen science to foster inclusive participation and intergenerational collaboration. Preliminary observations also point to the value of combining expert ecological monitoring with citizen-generated data to support robust biodiversity assessments.

As the project progresses, forthcoming analyses will clarify biodiversity patterns around solar farms, the quality of citizen-science contributions, and the applicability of this model across different European contexts. Overall, Bio_Solar illustrates the promise of participatory approaches for advancing a socially just and ecologically grounded energy transition.

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AI TEACHING ASSISTANTS FOR TEACHER EDUCATION: A MIXED-METHOD STUDY*

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Abstract

In the past two years, large language models have become an integral part of learning and teaching in schools and higher education. Given the rapid integration of artificial intelligence into everyday life, and into educational systems in particular, a comprehensive, multidisciplinary, and systematic approach is imperative to ensure both high-quality teaching and the development of essential learner competencies can be achieved effectively. Our team, proficient in diverse fields in both regular and special education, participated in a pilot program initiated by Bar-Ilan University. In this program, AI-based teaching assistants were developed for selected courses. Following this, we developed an AI-based teaching assistant specializing in planning, writing, and providing feedback on lesson plans and learning processes, which was then adapted into course-specific versions. Throughout the 2025 academic year, we implemented these assistants into our teacher education classes and conducted a mixed-method study using qualitative and quantitative questionnaires to examine students' perceived mastery and self-assessment of lesson planning skills. Participants included students in general education (n = 67), special education (n = 42), and a general education control group (n = 57). Findings indicate high student satisfaction and perceived support for clarifying assignment requirements and providing rapid, personalized feedback. In addition, there is qualitative evidence for the development of prompt literacy and critical monitoring. However, the analysis also highlights the importance of explicit instruction in prompt literacy and critical evaluation of AI outputs. These findings contribute to the emerging literature on integrating AI-based teaching assistants in teacher education.

Keywords: *AI teaching assistants, teacher education, lesson planning, self-regulated learning, formative feedback.*

1. Introduction

With the advent of large language models (LLMs) in late 2022, higher education institutions have begun experimenting widely with AI-based teaching assistants that generate text, simulate dialogue and provide feedback in response to student requests. These developments raise a central question for teacher education: how can AI tools be integrated in ways that support, rather than undermine, core pedagogical practices and professional judgement. Recent work suggests that custom AI assistants tailored to specific curricula, institutional policies and pedagogical goals can help align AI use with the values and standards of particular teacher education programs (Almasre, 2024; Masters et al., 2024).

Studies on educational chatbots highlight both opportunities and risks. Dedicated assistants can provide personalized guidance, timely feedback and accessible support, yet they also introduce challenges related to overdependence, academic integrity and fabricated outputs (Chang et al., 2023; Kuhail et al., 2023). Recent findings indicate that generative AI may reduce perceived cognitive effort and lower users' tendency to scrutinize AI generated responses (Lee et al., 2025). For teacher education this dual effect is especially significant: AI can restructure routine preparation and assessment tasks, but it may also weaken deliberate planning, critical reflection and adaptive decision-making. In this context, custom AI teaching assistants that are tightly coupled to local pedagogical frameworks appear particularly promising, since they can draw on course syllabuses, academic readings and policy documents to provide contextually appropriate feedback on lesson planning and related tasks (Almasre, 2024; Chang et al., 2023).

Our study is situated within a teaching training program at Bar-Ilan University's Faculty of Education, where careful planning of teaching and learning processes, and especially lesson planning, is regarded as a core professional skill across diverse educational settings. We developed an integrated knowledge base on lesson plan design that brings together generic principles, disciplinary perspectives and

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special education considerations. Two complementary tools were created using this shared corpus: A digital learning module that introduces and refreshes key concepts in lesson planning, and a family of custom AI chatbots. The latter includes a generic assistant for writing lesson plans, course specific assistants that combine course content with the shared lesson planning framework, and discipline specific bots that connect national curricula and teaching materials with the pedagogical model. These tools are intended to support students both in their coursework and in their school-based clinical practice.

Empirical work on such tightly coupled custom-designed AI tools in teacher education is still limited. Most existing studies focus on generic chatbots in higher education or on AI tools in specific subject domains (Almasre, 2024; Kuhail et al., 2023). There is relatively little evidence on how program-aligned assistants influence pre-service teachers' use of AI in lesson planning and how they experience such tools in their day-to-day practicum. Drawing on Zimmerman's framework for self-regulated learning, which conceptualizes learning as cycles of forethought, performance and self-reflection, this study examines how a custom assistant can support planning, monitoring and evaluation processes in the specific context of lesson planning (Zimmerman, 2000; Chang et al., 2023).

2. Background and related work

Early AI educational technologies focused on automated marking, plagiarism detection and basic tutoring systems with limited interactivity. Recent advances in large language models have enabled chatbots that generate context-sensitive responses, adapt to learners' inputs and provide ongoing formative feedback (Chang et al., 2023; Kuhail et al., 2023). These developments create new opportunities for guidance at scale, but also place fresh demands on teacher education, as future educators must learn to use such tools responsibly and critically.

Systematic reviews of educational chatbots highlight this inherent tension. Kuhail et al. (2023) show that chatbots can foster engagement, provide timely guidance and support large cohorts, yet they also raise concerns about accuracy, trust and the lack of robust evaluation frameworks. Chang et al. (2023) similarly emphasize that risks such as "hallucination", the production of plausible but incorrect information, require safeguards, especially in domains where precision is essential. Recent survey findings further suggest that generative AI may reduce perceived cognitive effort and lower users' tendency to scrutinize AI generated responses (Lee et al., 2025), reinforcing the need for deliberate pedagogical design.

Theoretical work on AI enhanced learning frequently draws on self-regulated learning (SRL) perspectives. Zimmerman (2000) conceptualizes learners as proactive agents who plan, monitor and reflect on their work. When AI assistants are designed around SRL principles, they can prompt students to clarify goals, track progress and adjust strategies, embedding planning, monitoring and evaluation cycles within a digital environment (Chang et al., 2023). From this perspective, the question is not only whether AI tools provide correct answers, but how they shape learners' habits of preparation, inquiry and reflection.

Within this broader field, custom AI tools have emerged as a particularly promising approach. Rather than relying on general purpose models, custom assistants are configured on domain specific corpora, such as course syllabuses, scholarly readings and institutional policy documents, in order to generate contextually appropriate, pedagogically aligned responses (Almasre, 2024). In a higher education design course, for example, a custom assistant was used to assess typography students' work, offering standardized feedback based on predefined criteria while remaining sensitive to course specific expectations (Almasre, 2024). Recent literature suggests that such tools can support personalized learning, consistent feedback, scalability and multilingual access for diverse student populations (Aithal & Aithal, 2024; Chang et al., 2023; Masters et al., 2024).

At the same time, scholars caution against uncritical adoption of generative AI in professional education. If lesson plans and pedagogical resources are produced too easily, there is a risk that preservice teachers will bypass essential processes of analysis, justification and reflective decision making. Authors therefore argue for "pedagogical alignment", in which AI tools are integrated into existing teaching frameworks as co facilitators rather than surrogates, and are accompanied by explicit training in critical evaluation of AI outputs (Lee et al., 2025; Masters et al., 2024). From a "glocal" perspective, global AI capabilities must also be tuned to local curricular standards, accreditation requirements and pedagogical traditions (Aithal & Aithal, 2024). In multilingual and multicultural educational settings, this implies careful curation of the knowledge base, ongoing verification of content and the incorporation of culturally relevant examples into chatbot interactions.

Against this backdrop, the present study examines a family of faculty designed custom chatbots that are tightly coupled to a shared lesson planning framework within a teacher education program. While previous work has often focused on generic chatbots or single course implementations, there is still limited empirical evidence on how program aligned assistants are actually used by students in a teacher training program, and how they experience the support these tools provide for both the completion of course requirements and aiding students taking part in practicum.

2.1. Research objectives

Our study seeks to address the following objectives:

1. To examine the contribution of integrating a chatbot as a teaching assistant in academic courses for pre-service teachers.
2. To investigate whether interaction with the chatbot assists pre-service teachers in improving their lesson planning skills through processes of receiving and implementing feedback
3. To identify key factors in the effective use of dedicated chatbots for the development of required skills in teacher education.

3. Method

3.1. Context and participants

In 2025, we enrolled 166 undergraduate students in courses focused on lesson planning and classroom practice. Participants were divided into three groups: Two experimental groups, one in general education and one in special education, whose coursework included a dedicated artificial intelligence teaching assistant, and a control group of general education students who did not use the AI assistant.

Using a mixed method approach, we combined quantitative survey data with qualitative accounts of students' experiences. A structured Likert type questionnaire was administered to three groups of pre-service teachers to assess their use of AI tools in lesson planning and their perceptions of the contribution of a dedicated AI teaching assistant. Students of the two experimental groups, who had direct access to the AI-based teaching assistant, also responded to two open-ended questions regarding the use of an AI teaching assistant in the course. The qualitative responses were analyzed thematically and used to complement the statistical findings, allowing us to interpret patterns of AI use and perceived support in light of students' own descriptions of when the assistant was helpful, when it fell short and what kinds of prompting and pedagogical conditions they regarded as necessary for effective use.

A total of 67 students were included in the experimental general education group, of which 48 students (71.6%) were female, and 19 students (28.4%) were male. In this group, 41 students (61.2%) were not teaching at the time of the study, 12 (17.9%) were teaching only as part of a school-based practicum, and 14 (20.9%) had at least one year of teaching experience. 51 students (76.1%) indicated no prior use of artificial intelligence before their studies at university, while 16 (23.9%) indicated previous use of artificial intelligence. An additional experimental special-education group comprised 42 students (25.3% of the sample), including 41 females (97.6%) and one male (2.4%). Most of these students (n=39, 93%) taught as part of their practicum during the study, and three students (7.2%) had teaching experience at least one year prior. There were 26 students (61.9%) in this group who had no prior experience with artificial intelligence tools, whereas 16 students (38.1%) reported experiencing them previously.

There were 57 general-education students in the control group (34.3% of the sample), including 46 women (80.7%) and 11 men (19.3%). Most (n=39, 68.4%) of the participants were not teaching at the time of the study, 8 (14.0%) were teaching as part of their practicum programs, and 10 (17.5%) had been teaching at least one year. Most of the students in this group (59.6%) had no prior experience with AI tools, whereas 23 (40.4%) reported having used AI tools before their studies at the university.

Across the full sample, 119 students (71.7%) were aged between 20 and 30, and 47 (28.3%) were aged 31 or above. Background variables - gender, age group, teaching status, and prior AI experience - were examined in relation to the dependent measures and included as covariates where statistically significant associations were found.

3.2. Instruments

Data for this study were collected using a self-constructed questionnaire developed specifically for the purposes of this research. The questionnaire included three sections:

Background: Participants answered background questions regarding gender, age group, teaching status (not teaching; practicum only; at least one year of teaching), and prior AI experience. Using these variables, we were able to characterize the sample and examine confounding factors.

Sense of Skill mastery: Participants answered questions assessing the extent to which they sense mastery in ten aspects of developing lesson plans, including writing goals and operational objectives, lesson structure planning, understanding levels of thinking according to Bloom's taxonomy, and identifying learning styles to enhance learning and more. Each item was graded on a five-point Likert scale. The internal consistency on this scale was high (Cronbach's $\alpha = .891$).

To evaluate the perceived contribution of AI teaching assistants to skill mastery, the two experimental groups rated the chatbot's contribution to their learning in six parameters, including, for example, whether the bot supported their learning process in the course, the extent to which it provided personalized responses to their questions and assisted them with assignments. Likert scale responses were scored on a scale of one to five. Cronbach’s alpha reliability coefficients for the perceived contribution of

AI teaching assistants were 0.79. In addition, they answered two open-ended questions about their experience with the chatbot assistant: the advantages of using the course bot and the ways it supported their work, and the main challenges they encountered during use.

3.3. Procedure and data analysis

In all three groups, students participated in regular teacher education courses focused on classroom practice and lesson planning. The two experimental groups were given access to a locally developed artificial intelligence teaching assistant integrated into the course as a support tool for planning, writing, and refining lesson plans. This assistant was not available to the control group during the course. All participants completed the first two sections of the questionnaire regarding background information and perceived skill mastery, while participants in the experimental group also responded to the third section assessing the perceived contribution of AI teaching assistants to skill mastery.

As part of the data analysis procedure, descriptive statistics (means and standard deviations) were calculated for each dependent variable. Using chi-square tests, group differences in background characteristics (gender, age, teaching status, prior experience with artificial intelligence) were analyzed. A control variable was included in subsequent analyses where background variables were significant predictors of dependent measures.

Using one-way analyses of variance (ANOVA), as well as Scheffé post hoc tests, analyses were conducted to compare the overall use of artificial intelligence tools in the three groups (general-education control, general-education experimental, special-education experimental). The significance of group differences was then tested by using two-way ANOVAs after controlling for age. A further independent samples t-test was conducted to compare AI use between the general education groups (experimental vs. control) and the experimental groups (general vs. special education). As a final step, Pearson product-moment correlations were computed to determine how students reported receiving help from the AI assistant in relation to overall AI usage, as well as separately within each experimental group.

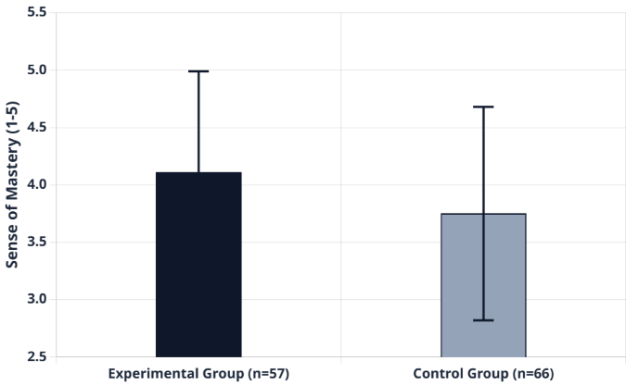
Open-ended responses from the two experimental groups were analyzed several times and coded inductively in order to identify recurring themes related to perceived benefits, challenges, and conditions for effective use of the chatbot assistant. These themes were then used to complement and interpret the quantitative findings regarding the use of artificial intelligence and the perceived contribution of the AI assistant.

4. Results

4.1. Quantitative findings

To examine the differences in the sense of mastery of skills between the experimental and control groups, independent samples T-tests were conducted. Significant differences were found between the groups in the skills of writing a complete lesson plan and writing operative objectives. These skills were higher among the experimental group that were taught using the AI chatbot assistant compared to the control group that did not take part in the study. Participants in the experimental group achieved significantly higher scores (M = 4.11, SD = 0.88, n = 67) compared to those in the control group (M = 3.75, SD = 0.93, n = 57), $t(121) = -2.15$, p = .033. Similarly, for writing operative objectives, the experimental group scored significantly higher (M = 3.91, SD = 0.82, n = 66) than the control group (M = 3.55, SD = 1.00, n = 55), $t(119) = 2.21$, p = .029. These results suggest that the use of AI teaching assistants had a positive impact on participants' performance, indicating that those who took part in the experimental group benefited more than participants who did not have the use of an AI assistant.

Figure 1. Sense of Mastery in Lesson Planning Skills: Experimental vs. Control Group.



Note. Error bars represent standard deviations (SD).

Regarding the perceived contribution of the custom AI assistant, participants in both experimental settings reported high levels of satisfaction. Perceived utility scores were comparable between general education (M = 3.97, SD = 0.79) and special education (M = 4.07, SD = 0.70). This uniformity suggests that the assistant's design, which integrates a shared pedagogical corpus with course-specific materials, effectively supports diverse learning needs across different educational tracks.

Correlational analyses revealed distinct disciplinary patterns in how students engaged with the technology: In the general education experimental group, overall, AI use was positively correlated with the assistant's specific contribution to planning lesson flow ($r = .26$, $p < .05$). In the special education group, an additional significant positive correlation was identified between using AI to diversify learning styles and the students' critical monitoring of the assistant's outputs ($r = .44$, $p < .01$).

4.2. Qualitative insights

Thematic analysis identified three key dimensions of the student experience:

Prompt literacy as a professional competency: Participants emphasized that AI efficacy depended on instructional precision. Learning to "ask properly" specifying operational goals and target audiences reframed the AI as a draft-generator requiring active professional guidance rather than passive adoption.

Contextual alignment and personalization: Students valued the assistant's ability to "speak the language" of the course through tailored pedagogical ideas. However, they displayed critical awareness by identifying technical limitations, such as difficulties synchronizing general and operational goals or designing cohesive closing activities.

Shift from technical resource to epistemic partner: Perceptions evolved from viewing AI as a technical aid to a learning partner facilitating self-study. Aligned with the SRL framework, students maintained that the tool cannot replace human reasoning, advocating for a "human-in-the-loop" model where AI outputs remain subject to rigorous professional critique.

5. Conclusion

This study examined how a customized artificial intelligence teaching assistant may help teacher-education students develop lesson-planning skills. Quantitative findings indicated substantial promise in enhancing perceived mastery among students who used the assistant compared to a control group. Qualitative analyses revealed support for clarifying requirements, providing efficient feedback, refining prompting skills, and fostering critical evaluation of AI outputs. Results suggest that program-aligned artificial intelligence tools can improve self-regulated and personalized learning when used purposefully and in conjunction with explicit instruction in prompt literacy and critical AI literacy. Integrating such tools in coursework and clinical practice may enhance consistency between theory and application. Limitations include a single institutional context and reliance on self-report measures. Future research should examine long-term classroom impacts, disciplinary variations, and performance-based assessments. As a whole, AI tools can enhance professional preparation when used as reflective partners that complement, rather than replace, ethical and evidence-based pedagogical judgment.

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FROM PERIPHERAL TO CORE: ENTREPRENEURSHIP EDUCATION IN THE CREATIVE INDUSTRIES

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Abstract

The European Union identifies entrepreneurship as a key competence for lifelong learning. However, across Europe's creative industries, including games, animation, and visual effects (VFX), graduates often complete their education with limited exposure to this competence, despite the prevalence of non-standard employment structures in these sectors. This study examined how entrepreneurship is perceived and integrated within higher education in the creative industries. Using thematic analysis of semi-structured interviews with 40 industry professionals, educators, and students, this study examined the perceptions, current practices, and barriers to implementing entrepreneurship education in games, animation, and VFX. The findings demonstrated that participants perceived entrepreneurial education as a vital competence in the creative sectors, particularly given the prevalence of freelance careers. However, its integration was affected by a combination of structural and cultural constraints, including the prioritisation of employability-driven metrics, curriculum overload, conflicts between entrepreneurial and creative values, and gaps in faculty expertise. Despite this, participants noted initiatives that can support entrepreneurship education, including using micro-credential models and reframing entrepreneurship to align with creative practice. Together, these findings highlight the importance of entrepreneurial competencies, the barriers to its integration, and the pathways through which higher education can better prepare graduates for careers in games, animation, and VFX.

Keywords: *Entrepreneurship education, entrepreneurial mindset, creative industries, games, animation, VFX.*

1. Introduction

Entrepreneurship has been identified as an important competence for navigating the increasing complexities of the global economy, characterised by rapid technological advances and expanding cross-sectoral collaborations (Mahmudin, 2023). In such conditions, professionals are required not only to possess sector-specific expertise but also the capacity to identify opportunities, adapt to change, manage risks, and implement innovative solutions in professional environments (Park & Kim, 2025; Corrêa & Jardim, 2025). Recognising these demands, several policy frameworks have been established, with the European Union, for example, identifying entrepreneurship as one of the eight Key Competences for Lifelong Learning. Within this policy framework, entrepreneurship is defined as "you act[ing] upon opportunities and ideas and transform[ing] them into value for others. The value that is created can be financial, cultural, or social" (Bacigalupo et al., 2016, p. 10). As such, this definition moves beyond the narrow association of entrepreneurship with start-ups and describes it as a multifaceted construct spanning personal development, employment, and self-employment pathways (Bacigalupo et al., 2016).

However, despite such policy recommendations, effectively integrating entrepreneurship education in formal education remains challenging due to a combination of conceptual, pedagogical, and institutional constraints. Specifically, research has highlighted the absence of a shared conceptual understanding of entrepreneurship, limited faculty expertise, and a lack of standardised teaching approaches, all of which can weaken teaching provisions. These challenges are compounded by curriculum overload within already intensive programmes, resource and funding limitations, and institutional resistance to pedagogical innovation, which further restricts effective integration (Fayolle & Gailly, 2008; Uddin et al., 2024; Mapanga & Faleni, 2025). Conventional teaching approaches may also prioritise theoretical or specialist knowledge over practical entrepreneurial skills, and even when implemented, entrepreneurship education is often offered as an optional or elective module (Corrêa & Jardim, 2025;

Mapanga & Faleni, 2025). Collectively, these factors position entrepreneurship as supplementary rather than integral to formal curricula.

The need for entrepreneurship education alongside creative and technical development is particularly pronounced in the creative industries, including games, animation, and visual effects (VFX), which operate within highly competitive and saturated job markets (Daniel & Daniel, 2015; Hassreiter et al., 2024). Employment in these sectors is frequently non-standard, encompassing self-employment, freelance roles, temporary contracts, part-time work, and project-based arrangements (IDEA Consult et al., 2021). In 2022, nearly 78% of the creative industry workforce in Europe was employed by micro-enterprises, with only 3.9% in large enterprises (Eurostat, 2025). Similarly, approximately 80% of game development companies have fewer than 10 employees (Laaninen & Wessman, 2023; Ecorys & KEA, 2023). Consequently, many small creative teams must compete directly with larger enterprises, intensifying the need for entrepreneurial capacity.

These employment structures emphasise the importance for creative industry professionals to balance artistic and technical expertise with financial and marketing skills (Koch et al., 2023), and to possess entrepreneurial capabilities such as opportunity recognition, negotiation, collaboration, network management, financial oversight, pricing, and risk management (Bacigalupo et al., 2016). Together, these factors underscore the importance of embedding business literacy and entrepreneurial competencies into creative curricula alongside technical skills (Laaninen & Wessman, 2023; Ecorys & KEA, 2023).

While entrepreneurship education is vital to the creative sectors, there is currently limited understanding of how the industry and educational institutions perceive its importance, and of the feasibility of integrating it into existing programme structures. This study aims to examine how entrepreneurship is perceived, how it may be integrated, and the potential challenges associated with integrating it within games, animation, and VFX curricula in Europe. In doing so, this study aims to understand the extent to which educational practices address entrepreneurial skill needs, in line with sector needs and EU policy.

2. Methods

This study is part of the PANEURAMA project (https://www.paneurama.eu/). Data collection involved semi-structured interviews with 40 participants comprising students and educators from higher education institutions (37%), and senior and junior industry professionals (63%) across the games, animation, and VFX sectors in 12 European countries (Hassreiter et al., 2025). Interviews lasted approximately 60 minutes each, were conducted online, and explored participants' perceptions of entrepreneurship and the opportunities and challenges associated with integrating entrepreneurship education into creative curricula. The semi-structured format allowed participants to share their experiences and perspectives in their own words, while ensuring that key themes relevant to the study's aims were systematically addressed. All participants provided written informed consent prior to their interviews, and the sampling method was purposive.

Interviews were transcribed verbatim using notta.ai to ensure accuracy and completeness of the data. Thematic analysis was employed to identify recurring patterns and themes within the interview data (Braun & Clarke, 2022). Data analysis was conducted using Atlas.ti qualitative data analysis software. Coding was performed by the second author, with codes systematically grouped into broader themes aligned with the study aims. This approach ensured that interpretations remained grounded in participants' statements while enabling analysis of the data.

To enhance the contextual relevance of the findings, preliminary results were presented at international conferences and panel discussions involving educators, students, and industry professionals across Europe, including FMX in Germany and MIFA in July 2025. These dissemination activities provided opportunities for refinement and contextualisation of the themes, helping to ensure that the interpretations reflected the diverse perspectives of the study participants.

3. Findings

Thematic analysis of the data identified three themes showing how entrepreneurship is perceived and the extent to which it is integrated within games, animation, and VFX education. Participants' conceptualisation of entrepreneurship extended beyond commercial gains to encompass a "mindset" towards taking initiative and having a sense of agency over realising ideas, which is needed to navigate the non-standard, freelance trajectories prevalent in these sectors. Participants also highlighted structural institutional constraints that limit the effective integration of entrepreneurship, and educational practices that could support its integration within creative curricula.

3.1. The importance and conceptualisation of entrepreneurship

This theme captures participants' perceptions of the importance of entrepreneurship and how it is conceptualised in relation to employment structures within the games, animation, and VFX sectors. The importance of entrepreneurship was highlighted by several participants, with one emphasising business literacy, stating: *"if we want influence in the world as artists, we need to understand what is business. And we need to have the business heart. We need to have the business soul."* The emphasis on having a *"business heart"* and *"business soul"* demonstrates the depth of importance placed on business understanding as a vital competency within creative industry education.

The importance of entrepreneurship was also linked to the realities of employment structures within the creative industries, particularly the prevalence of freelance work. Freelancing was described as a common early-career employment trajectory as a consequence of the limited availability of junior positions. One participant described this by stating: *"in general, I think people usually were forced to become freelancers right after university because not a lot of studios did hire junior people or graduates. […] So you cannot go to the safety net of a company."* In this context, freelancing is not associated with voluntarily pursuing an entrepreneurial career, but rather a response to job market conditions. This causes creative industry professionals engaging with entrepreneurial practices early in their careers to sustain employment, which one participant described, stating: *"you are becoming a legal entity as a freelance artist, which is a company."* Compounding this need for business and commercial literacy, freelance career trajectories also place importance in understanding the *"basics of marketing, even if it is just the marketing of themselves,"* alongside practical entrepreneurship skills such as planning for irregular work patterns: *"you have to plan for holidays and for times when there is no job… talking about marketing for freelancers, how you market yourself, how you find jobs."* In this sense, entrepreneurship within these sectors also encompasses understanding practical elements such as self-presentation and management, and preparing for financial uncertainty.

Finally, the conceptualisation of entrepreneurship extended towards a *"mindset"* associated with taking initiative and having a sense of agency in realising ideas. One participant articulated this by stating: *"it's more about introducing the mindset: you have an idea, you have a purpose or a drive, and then you find a way to make it happen. For me, entrepreneurship isn't just about making a profit […]. It's about getting something done."* This introduces another aspect of what encompasses entrepreneurship in the creative industries, which includes a way of thinking and translating creative ideas into concrete outcomes.

Taken together, this theme demonstrates that entrepreneurship is perceived to be vital within the creative industries due to the prevalence of freelance work. It is not merely conceptualised as the creation of a business, but as a mindset and skill set encompassing initiative-taking, self- and financial management, business literacy, and the willingness to make creative ideas happen. As such, entrepreneurship appears to be a vital competence for navigating creative careers.

3.2. Systemic constraints and cultural barriers

This theme discusses the influence of a range of factors extending from systemic institutional issues to attitudes towards business engagement that can impede the effective integration of entrepreneurship within the curricula of games, animation, and VFX.

In relation to systemic factors, participants described how employability outcome metrics are not tailored towards career trajectories within the creative sectors. One participant stated: *"so that metric which will go to be the main metric […] is the same across any training provider. […] the list that they've got of what they perceive as a graduate level job completely ignore arts subjects. They're not seen as anything that's important. So it's a problem…"* This highlights a limitation in the way graduate outcome metrics are designed and used. According to participants, these metrics do not appear to recognise creative-industry roles, which may influence survey outcomes and have implications for educational institutions. Consequently, some higher education institutions may be driven towards tailoring employability support to align with indicators reflected in graduate outcome surveys. One participant described this process, stating: *"universities are trying to make sure that students are absolutely happy… but also that they can work around this graduate outcomes survey. The employability team provided basic training… how to pass a job interview like it's an exam… No actual education in terms of what the industry… might want to go in, what their options are… [Staff were] dedicated to… coaching them [students] for the graduate outcome survey… ensuring that whatever students reported would technically fall under one of those categories… to make sure the rankings get bumped up."* This demonstrates how educational institutions may prioritise metric-driven outcomes, with potentially limited focus given to preparing graduates for the realities of working within the sector.

Curriculum overload was also identified as an issue, with one participant stating: *"the tricky part is fitting that [entrepreneurship education] into an already bloated curriculum. There's so much I want to teach, but I can't keep adding more because there's just no time. Plus, students often want to just focus on*

their projects...". This demonstrates that while teaching staff recognise the importance of entrepreneurship, curricula may not allow sufficient space for its inclusion. Therefore, educational institutions working towards curricula reforms should perhaps also address how entrepreneurship education can be integrated. Moreover, as illustrated by the quotes, students may also prioritise production work, possibly due to not recognising the longer-term career sustainability implications that an entrepreneurial understanding might offer. Alongside this, an expertise gap among educators could further hamper the effective integration of entrepreneurship education. This was described as follows: *"a lot depends on the teaching team behind each course. The entrepreneurial push really hinges on the profiles and experience of the instructors. So there's definitely still a clear need to upskill teachers to help foster that mindset more consistently."* This suggests that integrating entrepreneurship education is contingent on the backgrounds of teaching staff. Another issue associated with entrepreneurship education relates to conflicts around artistic values and being business-oriented. One participant described this by stating: *"I think the art people maybe are the most difficult ones, because quite often there is that 'we make art, not money', some kind of thinking. […] But I think this resistance is a global issue. We've been struggling with this a lot."* This demonstrates how personal values may influence willingness to engage with entrepreneurship among some students and professionals in these creative sectors.

Together, these accounts demonstrate how a mix of structural factors, including graduate outcome metrics, curriculum constraints, student prioritisation of production work, staff expertise gaps, and cultural values, may influence the feasibility of integrating entrepreneurship within creative industry education.

4. Institutional responses and initiatives to address gaps

This theme discusses both operational and potential educational institutional initiatives that could support the integration of entrepreneurship within creative curricula. Participants described a range of initiatives already in place within some institutions. One such example was the embedding of entrepreneurship as an institution level performance indicator. Supporting this, one participant noted: *"we did receive this one project funding […] to build more entrepreneurship […] Now we have it in our university strategy, entrepreneurship is written there and there are KPIs related to entrepreneurship in management level."* This demonstrates institution-level changes, suggesting that entrepreneurship is being recognised at a strategic level. Such embedding may facilitate curriculum updates and help address related challenges, including staff upskilling and student engagement with entrepreneurship education.

In addition, formal and informal educational structures were also referenced. One example was a minor in entrepreneurship: *"the minor entrepreneurship is for fourth year students and there we have students in from all the programs and also a bit from outside the university. About 40-50 students together… Some are just an idea phase, some already started something. They work every week daily together, then you get better connections."* This is an example showing how integrating entrepreneurship as a minor can function to engage with it without replacing core programme content. Alongside this, participants also referred to tailored support linked to innovation or project-based courses. One described institutional support for innovation projects, stating: *"we have these innovation projects and when they have finished it and came up with a good project… we help them to do that. That's a bit more tailored service for them."* This highlights how targeted guidance can be provided to students whose work shows potential for further development, supporting entrepreneurship through project continuation rather than standalone modules.

In addition to existing initiatives, participants discussed potential approaches for strengthening the integration of entrepreneurship education. One such approach involved reframing how entrepreneurship is conceptualised within the creative industries. One participant stated: *"we need to stop talking about this as only important for a startup… We need a vocabulary for something like art entrepreneurship. It's a different thing."* This suggests that reframing entrepreneurship in ways that align more closely with creative practice may support its integration within curricula. Such reframing could potentially address conflicts between artistic values and business-oriented thinking (discussed in the previous theme). This may also contribute to a shared understanding of what entrepreneurship education in the creative sectors entails.

Additionally, participants acknowledged micro-credentials as possible routes for introducing additional competencies within already packed curricula. One participant noted: *"[Our country] is actually kind of leading in Europe when it comes to micro-credentials… reskilling, retraining, and staying adaptable moving forward."* While the implementation of such models may depend on institutional approval processes and the availability of resources (e.g., both staff and funding), they may offer an option for integrating entrepreneurship education without restructuring full programmes. Finally, participants also acknowledged the value of four-year undergraduate programmes, which they perceived as offering greater flexibility than shorter programmes. While packed curricula were identified as an issue (in the previous theme), participants acknowledged how longer programmes could potentially allow space to integrate competencies such as entrepreneurship (alongside core disciplinary content). Acknowledging this, one

participant stated: *"one of the advantages we have at the undergraduate level is that our programs are four years long… That really gives us the space to focus not only on core disciplinary learning but also on broader educational opportunities."* Although updating curricula to include new content may still require navigating institutional approval processes, this indicates a degree of openness among teaching staff towards broader forms of integration. Together, these accounts demonstrate both existing practices and potential institutional pathways through which entrepreneurship education is, and could be, integrated within games, animation, and VFX education.

5. Conclusion

This study explored how entrepreneurship is perceived and integrated within higher education, particularly in relation to potential constraints in the games, animation, and VFX sectors. Our findings suggest that entrepreneurship is regarded as a vital competence in these creative fields, with participants conceptualising it as encompassing business literacy, a mindset oriented towards taking initiative, and self-management. Its importance was particularly emphasised in the context of freelance careers, which are common in these sectors. Several constraints to effectively integrating entrepreneurship were identified. These included institutions prioritising short-term gains reflected in graduate outcome metrics, curricula overload, tensions between entrepreneurial approaches and creative values, and gaps in teaching staff experience. Despite these challenges, the data also highlighted institutional practices and potential initiatives to support entrepreneurship education. Together, these findings demonstrate both the relevance of entrepreneurial education for creative careers and the factors that shape how it can be implemented within higher education.

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DEVELOPMENT SCENARIOS OF COLLABORATION IN THE FIELD OF INCLUSIVE HIGHER EDUCATION BETWEEN RUSSIA AND CIS COUNTRIES: PROJECT-FORESIGHT

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Abstract

The study describes the results of the first round of a foresight project conducted in July 2025, aimed at identifying promising scenarios for the development of cooperation between Russia and CIS countries in the field of inclusive higher education. The research was a continuation of two preliminary pre-foresight sessions held in the spring of 2025. An expert survey, developed based on the initially formulated scenarios, was sent to experts from Russia, Belarus, Kyrgyzstan, and Uzbekistan for refinement. Experts assessed the probability of six different scenarios across three-time horizons (5, 10, and 15 years) on a five-point Likert scale and selected the most probable scenario for each time interval. The key findings of the study demonstrate cautious optimism. In the short term (5 years), the most probable scenario is recognized as the realistic "Points of Growth" scenario, characterized by parallel national initiatives with the exchange of best practices. In the medium term (10 years), preference is given to the "Points of Growth – Regional Synergy" scenario, which implies the deepening of inter-university cooperation and the emergence of regional centers. The long-term forecast (15 years) shows a divergence of opinions but a clear shift towards more optimistic and cooperative scenarios, in particular, the "International Hub – Integration through Cooperation" scenario, indicating the experts' belief in the potential for deeper integration over time. Negative scenarios implying isolation or a minimal level of cooperation received the lowest probability ratings. The conclusion of the study is that experts believe in the progressive development of inclusive education within the EAEU space, but they view this process as gradual, starting with local initiatives. Russia is seen as a potential source of expert knowledge, but successful cooperation requires dialogue on equal terms and adaptation to national contexts. The main challenges noted by experts are institutional and cultural barriers, conservative attitudes, and a lack of funding, while human capital is named the key resource base for initiating changes. The main result of the first iteration was the refinement of the expert questionnaire for the subsequent, expanded round of the project-foresight.

Keywords: *Inclusive education, international cooperation, Russia, CIS countries, scenarios, expert survey.*

1. Introduction

Inclusive higher education is increasingly framed as a rights-based and development priority. International normative instruments explicitly require States to ensure non-discriminatory access to tertiary education and provide reasonable accommodation for students with disabilities (UN, CRPD).

These commitments were further articulated in the Salamanca Statement and Framework for Action, which positioned inclusion as a guiding principle for education systems and policy reform (UNESCO, 1994)

At the policy level, the inclusion agenda is reinforced by the Sustainable Development Goals, while global monitoring frameworks continue to document persistent exclusion and unequal participation of learners with disabilities across education levels, including higher education (UNESCO GEM, 2020).

Within the Commonwealth of Independent States (CIS), inclusive education in higher education is marked by a pronounced implementation gap: formal legal provisions have expanded, but institutional practices, resources, and socio-cultural readiness vary considerably across countries. In the Russian Federation, the organization of education for learners with disabilities is regulated, inter alia, by the Federal Law No. 273-FZ, including provisions on ‘special conditions’ and reasonable adjustments within education organizations (Russian Federation. Federal Law No. 273-FZ).

So, the development of inclusive higher education is a global priority, reflected in both international commitments and national strategies. Within the Commonwealth of Independent States (CIS), this process is characterized by significant diversity in approaches, legislative frameworks, and levels of practical implementation. While the formal principles of inclusion are often enshrined in law, their practical application in universities faces numerous institutional, cultural, and resource-related challenges.

Creating a collaborative space in this area is seen as a way to accelerate development, share best practices, and overcome common obstacles. This article presents the results of the preliminary (pre-foresight) stage of a study aimed at developing scenarios for cooperation between Russia and CIS countries in inclusive higher education. The goal of this stage was to formulate key hypotheses and potential development pathways based on a dialogue between experts from different countries.

2. Methodology: Pre-foresight expert sessions

The primary method for the initial data collection was the organization of two structured focus group discussions (pre-foresight sessions) in May 2025.

- The first session (May 22) involved experts from CIS countries: Belarus, Kyrgyzstan, Uzbekistan, and Kazakhstan.
- The second session (May 23) involved experts from leading Russian universities and organizations involved in inclusive education.

The discussions were moderated according to a pre-developed guide that covered the following key themes: the state of legislation, institutional practices, societal and cultural barriers, the role of various actors (teachers, parents, volunteers), the issue of employment for graduates, and prospects for international cooperation.

The sessions were transcribed, and their content was subjected to qualitative thematic analysis. The main task was to identify common problems, resources, and expectations, as well as to formulate possible scenarios for future interaction.

3. Key findings from expert discussions

3.1. Regulatory harmonization and the implementation gap

Experts across both sessions emphasized the discrepancy between formal legal commitments and actual institutional implementation. While several CIS countries have adopted inclusive education principles at the legal level, practical provisions for higher education remain uneven, with limited enforcement mechanisms and unclear entitlement structures (e.g., benefits for applicants with disabilities, service standards, and financing rules).

A recurring issue was the lack of reliable and comparable statistics on students with disabilities in universities, which complicates planning, benchmarking, and monitoring. In the CIS session, experts noted that even central authorities may not have readily available data on enrollment and support arrangements in higher education.

From a cooperation perspective, experts framed ‘harmonization’ less as formal unification and more as pragmatic alignment: shared definitions, comparable indicators, and interoperable guidance on ‘special conditions’ and reasonable accommodation in higher education.

3.2. Socio-cultural barriers: Stigma, disclosure, and student agency

Both CIS and Russian experts highlighted that stigma and fear of negative peer reactions are major barriers to inclusion in higher education. The willingness to disclose disability status was described as a sensitive ‘threshold’ that affects access to accommodations, psychosocial support, and participation in campus life.

Experts described cases where students avoided attending classes due to anticipated stigmatization, suggesting that legal provisions alone do not generate inclusive practices without sustained cultural change and campus-level interventions.

3.3. The ambivalent role of families and the ‘tutoring gap’

Family involvement was portrayed as simultaneously enabling and constraining. In the absence of formal tutoring and support services, parents often substitute institutional support; however, intensive guardianship can hinder autonomy, socialization, and transition to independent adult roles.

Experts also pointed to the need for alternative support infrastructures, including inclusive volunteering programs. Russian experts reported promising practices such as university-wide elective courses on ‘inclusive volunteering’, which can institutionalize peer support without making it coercive.

For cooperation agendas, these findings imply that cultural interventions and support service models (including volunteering and tutoring) should be treated as core elements of cross-country learning, not as optional add-ons.

3.4. Human resources and professional development

A consistent theme was the shortage of trained staff and the uneven integration of inclusion-related competencies into teacher education and continuing professional development. Belarus was discussed as demonstrating a more systemic approach, including long-standing curriculum components and structured professional development for faculty; other countries were described as being at early stages of institution-building in this area.

Experts recommended that cooperation prioritize scalable professional development formats (hybrid courses, joint modules, internships) and the preservation of effective elements of special pedagogy within inclusive didactics, avoiding ‘methodological dilution’.

3.5. Transition to employment and inter-agency coordination

Experts framed employment outcomes as a key indicator of inclusion effectiveness in higher education. Suggested solutions included: employer involvement in final assessments, development of career support networks, and partnerships with ‘strong’ employers able to offer adapted workplaces and sustain accommodation costs.

Russian experts emphasized that employment challenges cannot be solved by education authorities alone; effective solutions require inter-agency coordination, including labor and social protection institutions, as well as policies on quotas, benefits, and wage incentives.

3.6. Cooperation instruments: Hubs, monitoring, and coordination

On international cooperation, experts converged on the value of creating coordination and resource infrastructures. Proposals included a network of regional hubs (often linked to leading universities), common methodological packages, joint research programs, and a monitoring system with agreed indicators of university inclusiveness.

At the same time, experts cautioned against one-directional ‘donor–recipient’ dynamics. The most broadly supported vision was parity-based cooperation with mutual learning, where Russia is an important resource actor but not an unconditional leader.

4. Formulated cooperation scenarios

Based on the discussions, three preliminary scenarios for the development of cooperation were formulated:

1. Pessimistic Scenario ("Independent Initiatives / Sandboxes"): Each country develops its inclusive education system independently, with minimal cooperation. Interaction is limited to sporadic exchanges. This scenario is driven by a lack of mutual information, institutional barriers, and a focus on internal issues.

2. Realistic Scenario ("Points of Growth - Regional Synergy"): Development is based on parallel national initiatives with active exchange of best practices. Key elements include: regular conferences, mutual training for teachers, student exchanges, joint methodological developments, and the creation of a network of regional resource centers. Cooperation is gradual and parity-based.

3. Optimistic Scenario ("International Hub - Integration through Cooperation"): Deep integration with Russia playing a leading coordinating role. It involves harmonizing legislation, creating a unified competency center, implementing large-scale joint educational and anti-stigma programs, and forming a common monitoring system for the inclusiveness of universities.

Table 1. Describing of scenario.

Scenario	Core logic	Typical instruments (examples)
Pessimistic (‘Sandboxes / Independent initiatives’)	Minimal coordination; country-specific trajectories dominate; cooperation remains ad hoc.	Occasional conferences; small grants and pilot exchanges; open digital repository of materials; voluntary adoption of templates.
Realistic (‘Points of growth – Regional synergy’)	Gradual, parity-based cooperation via hubs and shared tools; emphasis on feasible alignment and peer learning.	Network of regional resource hubs; joint CPD modules; ‘inclusive audits’ and mobile expert teams; annual inclusiveness ranking; shared indicator set and monitoring platform.
Optimistic (‘International hub – Integration through cooperation’)	High integration with formalized governance; joint policy and data infrastructure; large-scale joint programs.	Interstate coordination council; model legal packages; unified database/monitoring; joint degree programs; cross-country anti-stigma campaigns; network career center for graduates with disabilities.

5. Discussion

The pre-foresight stage revealed a shared understanding of the fundamental problems in developing inclusive higher education in the CIS region, as well as a cautious optimism regarding the potential for cooperation.

Experts believe in progressive development but view it as a gradual process starting with local initiatives and exchanges (the "Points of Growth" scenario). In the long term, a shift towards more integrated forms of cooperation is considered possible.

Russia is seen as a resource but not as an unconditional leader. The success of cooperation depends on building a dialogue on equal terms, respecting national specifics, and focusing on mutually beneficial projects. The main challenges identified are legislative harmonization, overcoming cultural stigma, and securing funding.

The formulated scenarios served as the basis for the next research stage—a broader expert survey to assess their probability and desirability at different time horizons. The results of this pre-foresight phase underscore the importance of a multilateral expert dialogue as a starting point for designing a common future in the socially significant sphere of inclusive education.

The pre-foresight findings highlight that inclusive higher education cooperation in the CIS space is constrained by a combination of institutional, resource, and cultural factors. From a policy perspective, experts implicitly distinguish between ‘paper harmonization’ (formal similarity of legal norms) and ‘functional harmonization’ (shared operational definitions, indicators, and service standards that can be implemented and monitored). This distinction is consistent with rights-based interpretations of inclusive education, which emphasize not only access but also the provision of effective support and the removal of attitudinal barriers.

The strong preference for the realistic scenario can be interpreted as an expert assessment of political and administrative feasibility. Rather than endorsing rapid integration, experts prioritize ‘buildable’ cooperation components: hub networks, professional development modules, and shared monitoring tools. In the short term, these components can reduce coordination costs and create cumulative learning effects without requiring full legal unification.

Cultural stigma emerges as a central ‘bottleneck’ shaping the effectiveness of any technical or legal solutions. Experts’ emphasis on disclosure reluctance suggests that universities function as key agents of cultural change, where anti-stigma interventions, peer support, and inclusive volunteering can complement formal accommodations. This aligns with global evidence that attitudinal barriers remain a major determinant of educational participation for learners with disabilities.

The discussions also point to a structural ‘tutoring gap’: where dedicated support services are absent or underdeveloped, families become default support providers. While such substitution can enable participation, it can also reproduce dependency and impede student autonomy. For cooperation design, this implies that service models (tutoring, psychosocial support, assistive technology provision) should be explicitly addressed alongside infrastructure and legal topics.

Finally, experts’ focus on employment outcomes and inter-agency coordination indicates that inclusive higher education cannot be assessed in isolation from labor market structures and social protection policies. Scenario packages that include employer partnerships and transition support are therefore likely to be more sustainable, especially in contexts where resource constraints limit universities’ capacity to provide comprehensive services.

Limitations of the pre-foresight stage include the small number of experts and the qualitative nature of evidence. However, the sessions provided a high-resolution map of problem areas and feasible instruments, which can be operationalized in the next project stage through structured expert surveys and probability/desirability ratings for each scenario component.

6. Conclusion

The pre-foresight expert sessions identified a shared diagnosis of the main barriers to inclusive higher education in Russia and CIS countries: an implementation gap, limited data and monitoring capacity, insufficient staff training, persistent stigma, and fragmented transition-to-employment support. Experts' scenario preferences converge on a parity-based, incremental cooperation pathway (regional synergy), combining hub networks, shared tools, and monitoring. The scenario framework developed at this stage will inform the next round of project-foresight, where scenario components will be quantified and prioritized across time horizons.

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INCLUSIVE LEARNING ENVIRONMENTS: A RESEARCH IN TUSCAN SCHOOLS

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Abstract

In recent years, international pedagogical debate has increasingly highlighted learning environments as a key factor in the quality and equity of education. Research shows that the physical and organizational configuration of school spaces significantly affects teaching and learning processes, students' participation, well-being, and inclusion. Consequently, the design of educational spaces requires a close dialogue between pedagogy and architecture. In Italy, INDIRE has made a significant contribution by promoting a vision of the school as an integrated learning environment characterized by flexible and interconnected spaces. This approach was formalized in the 2016 *Manifesto 1+4 Learning Spaces for the New Millenium* and later expanded to explicitly address inclusion. Within this framework, learning environments are conceived as resources for collaboration, deep learning, differentiation, and participation, in line with Universal Design for Learning principles. Building on this theoretical background, the Regional School Office for Tuscany (USR Toscana) and INDIRE launched a research project to investigate the impact of PNRR-funded interventions on the transformation of learning environments in Tuscan schools.

Keywords: *Inclusion, learning environments, equity, well-being, Tuscan schools.*

1. Learning environments, inclusion, and educational innovation

Educational research has increasingly highlighted the deep interconnection between physical learning spaces and cognitive, social, and pedagogical processes. A substantial body of literature has demonstrated that the design and organization of educational environments influence not only learning outcomes, but also teaching practices, student engagement, well-being, and participation (Scott-Webber, 2004; Higgins et al., 2005; Manninen et al., 2007; Brooks, 2011, 2012; Cleveland, 2009). Within this perspective, learning spaces are no longer conceived as neutral containers for instruction, but as active components of the educational ecosystem, capable of shaping interactions, behaviors, and meanings. Building on this theoretical foundation, INDIRE's long-term research on Innovative Learning Environments (ILEs) has contributed significantly to reframing school space as a pedagogical device, deeply intertwined with curriculum design, inclusive teaching methodologies, and organizational practices. In continuity with the *Manifesto 1+4 Learning Spaces for the New Millennium*, INDIRE conceptualizes the school as a system of interconnected learning environments (formal, informal, individual, collective, and exploratory) designed to support diverse modes of learning and participation. More recently, this line of research has explicitly addressed the inclusive value of learning spaces, moving beyond a traditional focus on accessibility and architectural barriers. Drawing on the International Classification of Functioning, Disability and Health (WHO, 2001; Booth & Ainscow, 2016), INDIRE adopts a bio-psycho-social framework in which inclusion is understood as the result of the dynamic interaction between learners, educational activities, and environmental factors. Within this approach, space is conceived as a potential facilitator, or barrier, of participation, capable of either enabling or constraining students' opportunities to engage meaningfully in learning processes. INDIRE's empirical studies and professional development initiatives with schools highlight that inclusive ILEs are not designed for specific categories of learners, but aim to create "sufficiently good" conditions for all students, in line with principles of Universal Design and Universal Design for Learning (CAST, 2018). Flexibility, usability, symbolic value, and the possibility of multiple configurations emerge as key features of spaces that support inclusion, autonomy, collaboration, and well-being. In this sense, learning environments act as a "third educator", contributing to a broader cultural shift in which diversity is recognized as an educational resource and inclusion is embedded within everyday pedagogical practices, rather than treated as an exceptional or compensatory intervention.

2. INDIRE's research on inclusive learning environments

Since 2012, INDIRE has developed a sustained research focus on learning environments, highlighting their crucial role in fostering flexible, personalized, and innovative teaching and learning practices (Tosi, 2019). INDIRE's research is grounded in the assumption that the classroom cannot be considered the sole setting in which teaching and learning processes occur. Instead, it emphasizes the need to design educational spaces that go beyond the traditional model - originally conceived for mass schooling at the beginning of the twentieth century - in order to respond to the evolving needs of all learners and of contemporary society. This research trajectory has been consolidated in the *Manifesto 1+4 Learning Spaces for the new Millenium*, which outlines five distinct school spaces designed to accommodate different types of activities in relation to the teaching phase, educational goals and outcomes, class composition, and students' individual characteristics (e.g., talents, interests, vulnerabilities, and needs). The space identified as "1" is the *group learning space*, dedicated to collaborative learning. It represents an expansion of the traditional classroom, historically conceived as the sole locus of teaching and learning.

Over time, the focus on learning environments as a condition for inclusive schooling has been further developed (Caprino et al., 2022), drawing on the bio-psycho-social model proposed by the World Health Organization (WHO, 2007) through the ICF framework. Within this perspective, the *Manifesto* has been refined to provide guidelines, spatial settings, and design solutions aimed at promoting inclusive space design (Infante et al., 2023):

- The *group learning space* should ensure conditions that support physical well-being (adequate lighting, appropriate acoustics, ventilation, temperature control, and signage). It is the environment where students and teachers spend most of their time and should enable maximum participation by all learners and allow for the creation of cooperative work areas. Inclusivity in this space is reflected in its adaptability to individual students' needs, fostering collaboration, interaction, and spatial legibility for all users.
- The *individual area.* The individual area fosters students' autonomy and focus by supporting attention management, reducing sensory overstimulation, and providing a calm setting that promotes self-regulation and mental well-beingThe *Agora* represents the school space that opens up to the wider community. It should be accessible and equipped with an effective wayfinding system. This space fosters social inclusion and a sense of belonging, functioning as a hub for interaction among students, teachers, institutional and community stakeholders.
- The *informal area* should be easily accessible, clearly recognizable, and self-explanatory. It should include signage that encourages autonomous use, social interaction, and open communication. Inclusivity is enhanced through the presence of graphic and tactile supports, as well as digital and analog tools that facilitate expression and peer-to-peer exchange without mediation.
- The *exploration lab* is dedicated to the practical experimentation of knowledge acquired during lessons. It should be equipped with materials, tools, facilitators, and solutions that support differentiated and individualized approaches, as well as the use of digital and immersive technologies to enable multichannel representations and experiences, in line with CAST guidelines (2018). Additionally, it should allow for autonomous movement within the space, supporting orientation and enabling each learner to explore and develop their own talents.

The idea underpinning Indire's research on learning environments is therefore the need to move beyond a conception of the school as a mere aggregation of spaces dedicated to single activities (for example, the classroom for instruction, the laboratory for experiential activities, the gymnasium for physical activity, and corridors for circulation), towards the creation of an integrated environment characterized by permeability and continuity among different spaces (Tosi, 2019).

3. Methodology, research instruments, and phases of the study

In recent years, especially after the pandemic, Italian schools have received targeted funding to improve learning environments. The National Recovery and Resilience Plan (PNRR) has been central to this effort, supported by national design Guidelines later consolidated in Futura. Designing, Building, and Inhabiting the School, which now guide many PNRR-funded projects. These policies encourage moving beyond traditional classroom-and-corridor layouts toward integrated systems of complementary spaces (MIUR, 2013). Research also links learning environments to achievement, well-being, inclusion, and teachers' practices-insights reflected in the Futura framework.Building on this theoretical background, the Regional School Office for Tuscany (USR Toscana) and INDIRE have launched a research project to explore the impact of interventions funded through the National Recovery and Resilience Plan (PNRR) as well as other funding streams introduced following the COVID-19 pandemic. The study aims to provide a

shared opportunity for reflection to better understand the goals pursued, the results achieved, and their contribution to creating more inclusive, welcoming, and innovative schools. The study adopts a mixed-methods research design (Creswell & Plano Clark, 2018), which includes an initial phase of theoretical systematization, followed by standardized data collection through an online questionnaire. The collected data are mapped and analyzed to identify a set of cases of particular interest for in-depth case studies conducted in selected pilot contexts. The integration of quantitative and qualitative evidence supports the development of an interpretative framework that helps to describe how Tuscan schools are currently reconfiguring their learning environments. Accordingly, the research is structured into three main phases:

1. the first phase is the administration of a questionnaire - SET (Spazi Educativi Toscani) to school principals (or their delegates) to map the aims and types of interventions carried out;
2. the second phase consists in the analysis of the responses to identify a subgroup of particularly significant schools, followed by semi-structured online interviews with a representative sample (one school per educational level);
3. the third phase is the development of in-depth case studies based on selected schools, focusing on the relationship between spatial design, pedagogical innovation, and inclusiveness.

This ongoing research represents an important step toward understanding how investment policies can drive the evolution of learning environments as inclusive, flexible, and future-oriented educational ecosystems.

4. The SET questionnaire

The SET (Spazi Educativi Toscani) questionnaire was developed as a comprehensive research instrument to systematically explore how schools in Tuscany have designed, implemented, or planned transformations of their learning environments in recent years. Conceived within the collaboration between the Regional School Office of Tuscany and INDIRE's research unit on learning environments, the questionnaire aims to capture not only the physical characteristics of spatial interventions, but also the educational intentions, organizational processes, and contextual constraints that shape them. The structure of the questionnaire reflects a multidimensional understanding of learning spaces, aligned with the INDIRE framework on Innovative Learning Environments and with a conception of space as an active pedagogical and inclusive factor. The questionnaire is articulated into a sequence of thematic sections that combine structured response formats with opportunities for qualitative elaboration. An initial section gathers general and contextual information, including school level (early childhood, primary, lower and upper secondary education), institutional affiliation, and the role of the respondent, while also ensuring informed consent in compliance with data protection regulations. This section situates each response within its institutional and organizational context, allowing for comparative analyses across school types and educational stages. A first core section, dedicated to the recent past, investigates the types of spatial interventions carried out over the last three years. Respondents are presented with a detailed list of intervention typologies—ranging from new school buildings and regulatory upgrades (safety, seismic compliance, accessibility) to light refurbishment, aesthetic requalification, redefinition of the use of existing spaces, introduction of flexible furniture, conversion of underused areas, and interventions in outdoor spaces. For each intervention, schools are asked to indicate the level of implementation using a four-category response scale: implemented, in progress, planned but not implemented, or not planned. This structure enables the mapping of both completed actions and emerging design trajectories, highlighting different stages of spatial innovation across the region. Subsequent sections focus on the sources of funding that supported or enabled these transformations. Multiple-response options allow schools to indicate the use of national, European, and PNRR-related programmes (such as FESR, REACT-EU, Scuola 4.0, and other targeted initiatives), complemented by open fields for further specification. This section provides insight into the relationship between financial frameworks and design choices, supporting analyses of how funding opportunities influence the scope and nature of spatial interventions. The questionnaire then addresses the educational purposes that guided the design of learning environments. Respondents are asked to select up to three priority goals from a predefined list, including improving physical comfort and environmental quality, supporting active and laboratory-based teaching, fostering social interaction and informal learning, promoting student autonomy and participation, enhancing technological integration, supporting inclusion and cultural mediation, and opening the school to the wider community. By limiting the number of selectable options, the questionnaire encourages respondents to identify their most significant priorities, thus revealing the underlying pedagogical values associated with spatial design decisions. Another section explores the types of spaces involved in the interventions, using multiple-choice responses aligned with recognized categories of learning environments: differentiated classrooms, disciplinary or transversal laboratories, makerspaces, informal and shared areas, libraries, plenary spaces (such as agorà or auditoria),

outdoor learning environments, and spaces dedicated to staff and school governance. This section allows for an analysis of how different spatial configurations are distributed within schools and how they relate to intended educational functions. Further sections investigate the conceptual and cultural references that informed design choices, such as the *Manifesto 1+4* and INDIRE's research on learning spaces, internal school working groups, external providers, or requirements linked to funding calls. The questionnaire also examines the actors involved in the design process, inviting respondents to indicate the participation of school leaders, teachers, students, families, technical staff, external experts, and local authorities. This emphasis on participation and co-design reflects the recognition of spatial transformation as a collective and organizational process. Finally, the questionnaire addresses the main challenges and critical issues encountered during the planning and implementation of spatial interventions. Schools are asked to select up to three significant difficulties from a list that includes organizational resistance, lack of professional expertise, procurement and administrative constraints, market limitations, rising costs, and challenges in stakeholder involvement. Each section of the questionnaire is complemented by open-ended comment fields, allowing respondents to clarify responses, provide contextual explanations, and offer feedback on the clarity and effectiveness of the instrument itself.

Overall, the SET questionnaire integrates quantitative mapping with qualitative reflection, offering a robust tool to explore how spatial design, educational intentions, inclusion, innovation, and organizational dynamics intersect in contemporary school practices. By combining standardized response options with reflective commentary, the instrument supports both descriptive analysis and interpretative insight into the evolving role of learning environments in the Tuscan school system.

5. Results and discussion

The analysis of the SET dataset reveals a heterogeneous yet coherent picture of how schools in Tuscany are engaging in the transformation of learning environments. Overall, the data show that most interventions carried out in the last three years are not limited to large-scale construction projects, but rather focus on incremental and adaptive strategies, such as the redefinition of existing spaces, the introduction of flexible furniture, the conversion of underused areas, and interventions in informal or transitional spaces. This trend suggests a pragmatic approach to spatial innovation, in which schools operate within existing architectural constraints while seeking to enhance the pedagogical potential of their environments. Regulatory upgrades related to safety, accessibility, and compliance remain significant, but they are increasingly accompanied by design choices explicitly oriented toward educational and inclusive goals. The purposes guiding these interventions highlight a strong alignment with student-centred and inclusive pedagogies. Improving physical comfort and environmental quality, supporting active and laboratory-based teaching, fostering student participation, and enabling differentiated uses of space emerge as recurrent priorities. Notably, inclusion is rarely framed as a separate or compensatory objective; rather, it is embedded within broader aims related to flexibility, autonomy, social interaction, and well-being. This finding is consistent with the INDIRE perspective on Innovative Learning Environments, in which inclusive design is understood as the creation of "sufficiently good" conditions for all learners, rather than the adaptation of spaces for specific categories of students. The types of spaces most frequently involved in the reported interventions further reinforce this interpretation. Alongside traditional classrooms, schools report significant investments in informal shared areas, laboratories, makerspaces, libraries, plenary spaces, and outdoor environments. These choices indicate a gradual shift away from a classroom-centred model toward a more distributed learning ecosystem, where different spatial configurations support multiple forms of engagement, collaboration, and individual work. At the same time, the data show that these transformations are often inspired by internal school reflection and by INDIRE's research framework (particularly the *Manifesto 1+4*) rather than being driven solely by market solutions or funding requirements. From an organizational perspective, data highlight the central role of school leaders and teachers in the design process, with more limited but emerging involvement of students, families, and external stakeholders. While this points to a growing awareness of co-design principles, it also reveals a potential area for further development, especially in strengthening participatory approaches. The challenges reported by schools, such as resistance to pedagogical change, limited availability of suitable furnishings or professional expertise, administrative complexity, and rising costs, underscore that spatial innovation is not merely a technical issue, but a deeply cultural and organizational process. Taken together, the SET data suggest that schools in Tuscany are engaging in a meaningful transition toward more flexible, inclusive, and pedagogically intentional learning environments. This transition appears to be evolutionary rather than disruptive, grounded in local contexts and professional practices, and supported by a growing alignment between spatial design, educational values, and institutional vision. In this sense, the data provide empirical evidence of how learning spaces are increasingly conceived as strategic resources for innovation, inclusion, and participation within the everyday life of schools.

6. Conclusions and future work

This study examined the transformation of learning environments in Tuscan schools through the lens of INDIRE's research framework and within the policy context of post-pandemic investment programmes, particularly the National Recovery and Resilience Plan (PNRR). The findings show that schools are increasingly moving beyond a classroom-centred model toward more flexible, integrated, and pedagogically intentional learning environments, often through incremental and context-sensitive interventions rather than large-scale architectural transformations. The results highlight how inclusion is embedded within broader educational goals related to participation, well-being, flexibility, and autonomy, in line with bio-psycho-social and Universal Design for Learning perspectives. Learning spaces emerge as key mediators between pedagogical intentions and everyday practices, capable of supporting diverse learners through adaptable and multifunctional configurations. From an organizational standpoint, the study underscores the central role of school leadership and professional culture in guiding spatial innovation, while also pointing to the potential value of strengthening participatory and co-design approaches. Methodologically, the mixed-methods research design proved effective in capturing both systemic trends and contextual specificities, offering a robust analytical framework. From a methodological standpoint, the mixed-methods research design adopted in this study is highly replicable in other regional and territorial contexts. The combination of standardized data collection through the SET questionnaire, qualitative interviews, and in-depth case studies provides a flexible and scalable framework that can be adapted to different educational systems and policy environments. This approach enables regional authorities and research institutions to systematically monitor how investment policies are translated into spatial and pedagogical innovation, while also accounting for local specificities. As such, the methodology offers a transferable model for supporting evidence-informed decision-making and comparative analyses across regions.

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THE REALISE PROJECT – RESPONSIBLE EDUCATION AND LEARNING WITH ARTIFICIAL INTELLIGENCE IN SYSTEMS AND ELECTRONICS

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Abstract

The widespread availability of generative artificial intelligence (AI) tools is transforming university teaching practices, particularly in technical disciplines centered on programming, system design, and experimental validation. While these tools offer new opportunities for learning support and creativity, they also raise concerns regarding students' reasoning, autonomy, and professional ethics. The REALISE project—Responsible Education and Learning with Artificial Intelligence in Systems and Electronics—addresses this challenge through a pedagogical framework that promotes ethical, reflective, and responsible use of AI in engineering education. Developed at the School of Telecommunications Engineering of the Universidad Politécnica de Madrid (UPM), REALISE is implemented in three experimentally intensive courses: Laboratory of Electronic Systems (LSEL) in the Master's in Electronic Systems Engineering (MUISE), and Sectorial Applications (APSE) and Projects in Data and Systems Engineering (PIDS) in the Bachelor's in Data and Systems Engineering (GISD). The methodology combines project-based learning with explicit documentation of students' interactions with AI tools, requiring justification of prompts, generated outputs, corrections, and critical reflections. In LSEL, authentic learning is reinforced through real sensor measurements, diversified hardware configurations, practical constraints, and debugging of intentionally faulty code. In APSE and PIDS, students actively build and curate datasets for AI model development, fostering awareness of data quality, representativeness, and bias. REALISE aims to integrate "Responsible AI" as a transversal competence, strengthen analytical and documentation skills, and generate transferable educational materials for broader adoption. The project contributes to the modernization of engineering education by promoting a human-centered and ethically grounded digital transformation.

Keywords: *Artificial intelligence, responsible education, educational innovation, critical thinking, ethics, assessments and measurements in education.*

1. Introduction

Generative artificial intelligence (AI) tools are rapidly reshaping higher education, particularly in engineering disciplines where programming, system design, and experimental validation are central. Although AI can support learning, prototyping, and documentation, it also challenges the development of reasoning skills, autonomy, and professional ethics. In technical contexts, syntactically correct code generation does not guarantee conceptual understanding or engineering competence.

The REALISE project (Responsible Education and Learning with Artificial Intelligence in Systems and Electronics) proposes a formative and ethical integration of AI into engineering education. Instead of restricting AI use, REALISE redesigns learning activities and assessment strategies so that AI functions as cognitive support while responsibility for reasoning, validation, and decision-making remains with the student. Developed at the School of Telecommunications Engineering of the Universidad Politécnica de Madrid (UPM), REALISE builds on prior challenge-based learning experiences that integrated AI into electronics education and demonstrated improvements in engagement and practical competence (Bravo-Pacheco et al., 2025). The framework is grounded in the Semantic Bridge paradigm, which provides a theoretical basis for understanding the limitations of AI in experimental engineering contexts and for designing learning scenarios that foster deep understanding and critical thinking.

2. The semantic bridge paradigm

The Semantic Bridge paradigm distinguishes between syntactic information and semantic meaning in engineered systems. Digital systems operate on symbols, data structures, and signals according to formal rules, but functional meaning emerges only when these elements are interpreted within a physical or

operational context. Similar notions appear in ontology-based integration, where semantic bridges connect heterogeneous conceptual spaces (Ambalavanan et al., 2025), and in enterprise AI through semantic data contracts that formalize shared meaning across data pipelines (Kuthuru, 2025).

Generative AI models primarily operate at the syntactic level, identifying statistical regularities in symbolic representations. Although their outputs may appear coherent, these models lack direct access to physical reality and cannot autonomously establish causal relationships between digital representations and real-world behavior. This limitation is particularly evident in experimental domains such as embedded systems and electronics, where validation against physical constraints is essential.

Recent research has explored algorithmic realizations of semantic bridges through structured representations such as Abstract Meaning Representation (AMR) graphs (Semantic Bridge, 2025). These approaches provide valuable insights into how semantic structure can be formally represented and manipulated, particularly for symbolic reasoning and interpretability. In the context of engineering education, however, our work extends this perspective by emphasizing semantic grounding through experimental interaction with physical systems.

From an educational perspective, meaningful learning occurs when students actively construct or reconstruct the semantic bridge linking abstract representations (code, models, data) to their physical or functional consequences. By intentionally designing tasks where this bridge is incomplete or context-dependent, students are required to reason, experiment, and interpret results. In such settings, AI may assist with syntax or documentation, but it cannot replace the student's role in constructing meaning.

3. Educational context and objectives

Previous implementations of embedded AI technologies in laboratory subjects have shown that combining hardware experimentation with AI-based components effectively supports the development of practical AI skills in electronics students (Gil-Martín et al., 2023). REALISE is implemented across three courses with strong experimental components:

- Laboratory of Electronic Systems (LSEL), Master's in Electronic Systems Engineering (MUISE).
- Sectorial Applications (APSE) and Projects in Data and Systems Engineering (PIDS), Bachelor's in Data and Systems Engineering (GISD).

These courses involve open-ended problems using hardware platforms, sensor data, and system-level constraints. Integrating AI in this context requires careful pedagogical design to preserve learning objectives related to reasoning, validation, and ethical responsibility.

The project objectives are:

1. To integrate responsible and reflective AI use as a transversal competence.
2. To promote critical thinking, autonomy, and self-regulation.
3. To design activities resistant to fully automated resolution.
4. To strengthen technical documentation and objective evaluation skills.
5. To generate transferable methodologies and educational materials.

4. Methodology and instructional design

The instructional approach combines project-based learning, experimental validation, and personalized problem settings. Each student or group interacts with unique hardware configurations, datasets, or constraints, limiting the effectiveness of generic AI-generated solutions. Activities include real sensor data acquisition, hardware diversification, and realistic constraints related to energy, timing, or environmental conditions.

A core methodological element is the explicit documentation of AI usage. Students must record prompts, generated outputs, applied corrections, and a critical assessment of AI suggestions. This shifts assessment from final results to learning processes, fostering metacognition and ethical awareness while positioning AI as an assistive tool rather than a substitute for reasoning.

5. Implementation scenarios

5.1. Laboratory of electronic systems (LSEL)

In LSEL, learning activities are explicitly designed to reinforce semantic grounding through interaction with real hardware, heterogeneous configurations, and experimental validation. Students work with physical sensors, acquire real measurements from their environment, and deploy solutions under realistic constraints related to timing, energy consumption, and environmental variability. Hardware

configurations are intentionally diversified across students or groups, ensuring that system behavior cannot be fully anticipated from abstract specifications alone.

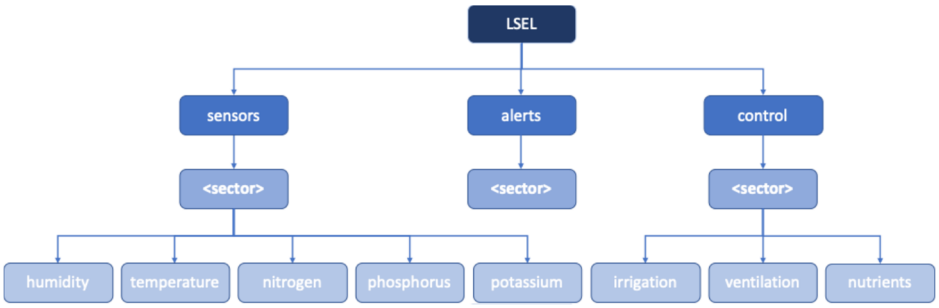
A central strategy in LSEL is the deliberate introduction of semantic friction between abstract representations and observable system behavior. Students are frequently required to debug intentionally faulty code fragments, where errors are not purely syntactic but contextual—for example, incorrect assumptions about sensor behavior, communication timing, or peripheral configuration. These tasks force students to reason about causality, validate hypotheses experimentally, and iteratively refine their designs, thereby constructing the Semantic Bridge between code and physical behavior.

5.1.1. Exam design and semantic grounding. As a concrete implementation of this paradigm, LSEL adopts an individual, hands-on examination model centered on MQTT-based communication, a widely used protocol in embedded and IoT systems (HiveMQ, 2023). The exam requires students to design, implement, and execute a publish–subscribe system that interacts with a live MQTT broker, emphasizing operational correctness, interpretation of runtime behavior, and system-level reasoning.

Rather than assessing the reproduction of known code patterns, the exam evaluates the student's ability to translate abstract protocol concepts—such as topics, publishers, subscribers, and message semantics—into a functioning cyber-physical system.

Figure 1 illustrates the hierarchical MQTT data model provided to students as part of the exam scenario. While the syntactic structure of sensing, alerting, and control domains is explicitly defined, the operational semantics of each branch must be inferred, implemented, and validated through system execution. This partial specification deliberately requires students to construct the Semantic Bridge between abstract communication structures and observed system behavior.

Figure 1. Hierarchical MQTT data model used in the exam scenario.



The assessment context is intentionally underspecified at the syntactic level, requiring students to interpret requirements, justify design decisions, and validate system behavior through execution and observation. Table 1 summarizes the exam context, communication infrastructure, and semantic constraints imposed on data exchange, while Table 2 outlines the structure of the exam exercises and their associated reasoning focus.

Table 1. MQTT Exam Context and Data Model.

Element	Description
Scenario	Smart greenhouse monitoring and control system
Broker	IP: 10.8.42.100, Port: 1883
Topic hierarchy	Sensors / Alerts / Control
Personalization	Sector ID embedded in topics
Payload constraints	Numerical (sensors); {ON, OFF} (control); categorical (alerts)

Table 2. Exam Exercises and Assessment Focus.

Exercise	Core Task	Reasoning Focus
1) Data aggregation	Subscribe and compute rolling averages	Interpretation of live data
2) Alert generation	Detect anomalies and publish alerts	Semantic threshold reasoning
3) Hierarchical control	React to macro-sector alerts	System-level contextual reasoning

The effectiveness of this exam model lies in the fact that successful completion depends on the alignment of three elements: syntactic correctness (valid code and protocol usage), semantic interpretation (meaning of data and messages), and contextual validation (observed system behavior). While students may consult AI tools for syntax reminders or library usage, AI-generated solutions alone are insufficient, as they

cannot infer runtime behavior, diagnose context-dependent faults, or validate decisions against experimental outcomes.

From a responsible AI perspective, this exam design naturally constrains misuse while explicitly allowing AI as a support tool. Students remain accountable for interpretation, debugging, and validation, ensuring that AI augments—rather than replaces—engineering judgment.

Table 3. Comparison between traditional assessment models and the REALISE exam model.

Dimension	Traditional Exam Model	REALISE Exam Model
Nature of the task	Predominantly theoretical or template-based coding exercises	Individual, hands-on implementation in a real execution environment
Focus of assessment	Correctness of final answer or code output	Reasoning process, system behavior, and experimental validation
Contextual grounding	Abstract or simulated scenarios	Real communication scenarios with live brokers and runtime interaction
Role of code	End product to be evaluated	Medium for demonstrating understanding and decision-making
Treatment of AI tools	Often implicit or uncontrolled	Explicitly allowed as support, but insufficient for task completion
Resistance to automation	Low: solutions can often be generated directly by AI	High: requires semantic grounding, execution, and debugging
Evaluation perspective	Result-oriented	Process-oriented and reflective
Skills emphasized	Memorization, syntax, procedural reproduction	System-level reasoning, interpretation, autonomy, and critical judgment

Table 3 summarizes the key differences between conventional assessment approaches and the exam model adopted in the REALISE framework. While traditional exams tend to prioritize syntactic correctness and reproducibility of expected solutions, the REALISE model deliberately relocates assessment to the construction of meaning at the system level. By requiring students to execute, observe, and interpret the behavior of a live MQTT-based system, the exam enforces the active reconstruction of the Semantic Bridge between abstract protocol descriptions and their functional manifestation in a real environment. This shift not only increases resistance to automated solution generation, but also aligns assessment with the core learning objectives of experimental engineering: reasoning under uncertainty, validation through observation, and responsible use of computational tools.

5.2. Sectorial applications (APSE) and projects in data and systems engineering (PIDS)

In the Sectorial Applications (APSE) and Projects in Data and Systems Engineering (PIDS) courses, the REALISE framework is applied at a higher level of abstraction, focusing on data-centric and system-level AI design. Students actively participate in the creation, curation, and analysis of datasets used to develop AI-based systems, fostering concrete awareness of data quality, representativeness, and bias. This hands-on involvement makes explicit the ethical and technical implications of data-driven decisions and mirrors professional practices such as the use of semantic data contracts to ensure accountability and shared understanding across AI pipelines (Kuthuru, 2025).

The central project in APSE and PIDS involves the design of gesture-based Human–Computer Interaction systems, aligned with current research in embedded hand-gesture recognition and Edge AI (Esteban-Romero et al., 2025; Gil-Martín et al., 2025). Students implement complete processing pipelines—including data acquisition using MediaPipe landmarks, model training, and embedded deployment—on resource-constrained platforms such as the Raspberry Pi. Inference is performed locally, reinforcing privacy-by-design principles and exposing students to real deployment constraints.

From a pedagogical standpoint, this scenario operationalizes the Semantic Bridge paradigm at the data level. Students must define what their data means—how gestures are labeled, how variability is handled, and how preprocessing choices affect downstream behavior. While generative AI can assist with scripting, automation, or exploration of alternative architectures, it cannot replace the physical act of data collection nor the contextual interpretation of model behavior under real-world conditions.

A key learning outcome is the explicit analysis of trade-offs between model accuracy, computational cost, and system responsiveness. Students are required to justify architectural choices and assess whether performance gains justify increased complexity under embedded constraints. This reflective process reinforces responsible AI use by making limitations, assumptions, and consequences visible and subject to critical evaluation.

6. Evaluation framework

REALISE currently adopts a formative evaluation strategy based on student questionnaires, reflective reports, and instructor observations, focusing on autonomy, reasoning effort, and AI usage patterns. Qualitative analysis of technical documentation emphasizes justification, validation, and critical assessment of AI outputs. Future extensions include AI-assisted analysis of reflective artefacts and interaction logs to identify patterns in reasoning and AI usage. These tools are intended to augment, not replace, human judgment and will follow the same principles of transparency and responsibility promoted in learning activities.

7. Discussion

The REALISE framework contributes to ongoing discussions on how engineering education can remain pedagogically meaningful in the presence of increasingly capable generative AI tools. Rather than treating AI as a threat to assessment integrity, this work demonstrates that learning activities and evaluations can be redesigned so that understanding, experimentation, and interpretation cannot be trivially automated.

The Semantic Bridge paradigm provides a unifying lens across courses, revealing a structural limitation of AI in experimental and system-oriented domains: the inability to autonomously ground abstract representations in physical or contextual meaning. By positioning assessment tasks at this boundary, REALISE re-centers evaluation on human judgment, validation, and responsibility. At the same time, the framework highlights practical challenges, particularly the increased demand for reflective documentation and process-oriented assessment. Addressing scalability through carefully designed AI-assisted evaluation tools—used transparently and responsibly—emerges as a necessary complement to the pedagogical approach rather than a contradiction of it.

8. Conclusions and future work

This paper has presented the conceptual foundations and instructional design of the REALISE project, an educational framework for responsible and reflective AI integration in engineering education. Grounded in the Semantic Bridge paradigm, REALISE demonstrates how learning activities and assessments can remain meaningful and resistant to trivial automation.

Future work will focus on systematic empirical evaluation, refinement of assessment instruments—including controlled AI-based analysis—and transfer of the methodology to other engineering disciplines and institutional contexts.

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"WHAT'S NEXT?": A PROJECT-BASED STEM WORK EXPERIENCE MODEL FOR FUTURE TECHNOLOGISTS

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Abstract

This paper aims to present and evaluate 'What's Next?', a project-based STEM work experience model designed to bridge classroom learning and industry readiness for secondary pupils. Unlike typical STEM placements, the programme combines agile rituals, peer-led teaching, and structured reflection against 17 competencies, creating a distinctive approach that blends technical practice with metacognitive and civic dimensions. We designed "What's Next?" to feel like a real week in a software team. In collaboration with Cardiff Commitment and Technocamps, pupils in Years 10–12 stepped into roles, ran sprints, built educational tech, and then taught younger learners using what they had made. Over two summers (2023–2024), demand grew from 28 to 32 places from ~80 applicants, and in 2025, 96% of participants said they would recommend the programme. In this paper, we tell the story of how the week works—day by day—why we chose agile rituals and accessible tools (Minecraft Education, LEGO® SPIKE™, BBC micro:bit), and how daily reflection against 17 skills connected classroom learning with workplace expectations. We situate the design within the Curriculum for Wales Digital Competence Framework and the Cardiff Commitment ecosystem and draw on evidence from STEM project-based learning, agile pedagogy, and game/robotics-based education. The narrative offers a replicable pattern for schools, universities, and employers who want to build inclusive, high-engagement STEM work experiences that align with regional skills needs (Department for Education, 2025; Open University in Wales, 2025).

Keywords: *STEM education, project-based learning, work experience, agile learning, digital competence.*

1. Introduction

The starting point was simple: young people need earlier, better, and more authentic encounters with digital work. In Wales—as across the UK—employers continue to report skills shortages, particularly in AI and digital roles, and they call for structured, inclusive routes into those fields (Department for Education, 2025; Open University in Wales, 2025).

Policy already points in the same direction. The Curriculum for Wales makes the Digital Competence Framework (DCF) a mandatory cross-curricular skill, positioning digital capability alongside literacy and numeracy (Hwb, 2018; Hwb, 2025). Locally, the Cardiff Commitment convenes schools, employers, and universities to open "eyes and doors" to work, creating partnerships for experiences that matter to pupils (Cardiff Commitment, 2022; Cardiff Commitment, 2025).

Within this ecosystem, we built "What's Next?" as a week that feels like real software engineering: problem framing, sprints, stand-ups, demos, and retrospectives—culminating in delivering workshops to primary pupils. We drew on Technocamps' national network, which offers free STEM outreach and teacher professional learning across all Welsh universities (Technocamps, 2025; Swansea University, n.d.).

What distinguishes this model from other experiential STEM programmes is its integration of agile rituals, peer-led teaching, and structured reflection against 17 competencies—elements rarely combined in short-term work experiences. These features make the programme unique in blending technical practice with metacognitive and civic dimensions.

2. The story so far: Why a week, why agile, why these tools

We chose a single, immersive week to create momentum and purpose. A short, time-boxed project offers the urgency that many pupils find motivating, while still allowing for iteration and reflection (Rehman et al., 2024; Balemen & Keskin, 2018). Day 1 begins with a paper-airplane simulation: pupils experience planning, a sprint, a review, and a retrospective—plus a shared Definition of Done.

The simplicity of paper and the physicality of flight make agile ideas stick (Frydenberg, Yates, & Kukesh, 2018; Agile Alliance, n.d.).

From there, teams select a brief: build an educational resource we can deliver to primary pupils. Some choose Minecraft worlds to teach biodiversity or cybersecurity; others design SPIKE™ robots or micro:bit systems to explore sensing and data. The toolkit matters: Minecraft, SPIKE™, and micro:bit lower barriers to entry and support mixed-ability teamwork, which research links to engagement, creativity, and inclusive participation when tasks are scaffolded (Sariçam & Yildirim, 2021; Nebel, Schneider, & Rey, 2020; Micro:bit Educational Foundation, 2025; Education Business UK, 2023).

3. Pedagogical frame: Design–build–test–teach

Our week follows a design–build–test–teach cycle. Teams define a problem and audience, prototype solutions, test with peers, and then teach primary pupils using their artefacts. Project-based learning (PBL) meta-analyses consistently report positive effects—often moderate to large—for science and STEM achievement and creativity when experiences are authentic and well scaffolded (Balemen & Keskin, 2018; Kwon & Lee, 2025; Cao et al., 2025). Agile rituals provide the metacognitive spine that keeps PBL moving: planning focuses attention; reviews promote feedback; retrospectives turn experience into improvement (Frydenberg, Yates, & Kukesh, 2018; Agile Alliance, n.d.).

Because game-based and robotics tools can increase cognitive load if used without structure, we build micro-rubrics and checklists for each tool. Evidence on Minecraft shows engagement is high but learning gains depend on careful scaffolding and alignment to outcomes (Tablatin, Casano, & Rodrigo, 2023; Minecraft Education, n.d.). Similarly, SPIKE™ and micro:bit are most effective when tasks are purposeful and inclusive, supporting computational thinking and collaboration (Education Business UK, 2023; Mardian & Azzahra, 2024).

4. What happens during the week: A narrative walkthrough

On Monday morning, the room feels like a studio: sticky notes on the wall, teams huddled around paper airplanes. By the afternoon, pupils have self-selected roles—product owner, developer, tester—and they have set their Definition of Done. Tuesday is build day: one team tinkers with redstone logic in Minecraft to model secure doors in a “cyber lab,” while another gets its SPIKE™ robot to sort coloured bricks using a light sensor. In a corner, a micro:bit group is logging blue-tooth signal strength to demonstrate how data changes with distance. Each team runs a stand-up, shows progress, and captures feedback (Frydenberg, Yates, & Kukesh, 2018; Tablatin, Casano, & Rodrigo, 2023).

Wednesday is iteration. We encourage pupils to test with peers and revise based on what primary pupils will need. Research on informal STEM PBL suggests small group sizes, clear assessment, and appropriate duration amplify effects; we intentionally keep teams compact and the project time-boxed (Santhosh et al., 2023; Rehman et al., 2024).

Thursday pivots to presentation and pitching. Industry volunteers (e.g., Red Hat) run short sessions on speaking clearly, telling a story, and building confidence. Friday is delivery day: pupils teach primary classes with their own materials. The act of teaching consolidates understanding and gives immediate, human feedback—smiles, questions, and moments of “I get it now” (NatCen/SQW, 2017; CEDEFOP, 2018).

5. Evaluation: What we heard, what we saw

Evaluation draws on mixed methods: daily self-assessments across 17 skills, mentor observations, and end-of-week surveys. These instruments capture both perceived and observed growth in technical and employability skills, aligning with best practices for experiential learning assessment.

We capture daily self-evaluations across 17 skills (teamwork, communication, dependability, productivity, initiative, problem-solving, and more) and mentor observations, then a cohort survey on Friday. In 2025, 96% of pupils recommended the programme; perceived gains were strongest in teamwork, communication, and project management. These findings mirror UK evidence that structured work-experience activities build employability skills when well prepared and debriefed (NatCen/SQW, 2017; CEDEFOP, 2018).

Participants loved the hands-on, collaborative feel—especially LEGO-based engineering and team project development—but they asked for more kits, clearer scheduling, and deeper technical content. Those requests align with the literature: resources and scaffolding mediate PBL outcomes, and technical depth should be staged as confidence grows (Santhosh et al., 2023; Balemen & Keskin, 2018).

6. Reflections: What made the difference

Four elements mattered most. First, authenticity: designing for real primary pupils adds purpose and quality stakes. Second, agile as shared language: rituals and definitions kept projects moving and gave teams agency. Third, accessible tooling: Minecraft, SPIKE™, and micro:bit allowed everyone to contribute somewhere—build, code, test, present. Fourth, regional infrastructure: the DCF and Cardiff Commitment lent curricular legitimacy and connected us to employers and schools (Hwb, 2018; Cardiff Commitment, 2025).

We also recognise limits. Our evaluation is short-term and self-report heavy. Next, we will introduce pre/post rubrics keyed to DCF strands, add artefact quality ratings, and track medium-term outcomes (e.g., enrolment in CS qualifications, apprenticeships), responding to calls for structured skills plans and evidence-backed pathways (Open University in Wales, 2025; Department for Education, 2025).

7. Replication guide: Practical steps for schools, hubs, and employers

Start with a one-week frame and a paper-airplane agile simulation on Day 1; keep teams small and goals clear. Build briefs around real audiences (e.g., a local primary class) and a Definition of Done. Use frequent demos and retrospectives to manage scope and surface learning (Frydenberg, Yates, & Kukesh, 2018; Careers & Enterprise Company, 2017).

Choose accessible tools and scaffold them with micro-rubrics; budget for enough SPIKE™ and micro:bit kits to reduce bottlenecks; borrow or share kits across a local network. Map tasks explicitly to the DCF to support buy-in, and draw on city or regional initiatives (e.g., Cardiff Commitment) for employer talks and school links (Hwb, 2018; Cardiff Commitment, 2025).

Evaluate every day. Pair pupil self-ratings with mentor notes and artefact reviews. Build a simple pre/post rubric for computational thinking, collaboration, and communication, and track progression across terms where possible (NatCen/SQW, 2017; CEDEFOP, 2018).

8. Conclusion

"What's Next?" shows that a short, agile, and authentic work-experience week can make STEM feel accessible, purposeful, and communal. Pupils leave with stories of what they built and taught—and with clearer language for how teams plan, test, and improve. With modest resourcing, strong partnerships, and careful scaffolding, this model can be replicated across schools and hubs to strengthen regional pipelines into digital careers (Technocamps, 2025; Universities Wales, 2018).

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AN INTEGRATED EDUCATIONAL CONTENT ON WATER SECURITY AS A TOOL FOR ACHIEVING SUSTAINABLE DEVELOPMENT GOALS

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Abstract

Modern higher education requires a strategic shift toward student-centered and competence-based approaches, as emphasized by the Bologna Process and the EHEA communiqués from Yerevan, Paris, and Rome. A critical challenge remains the formation of educational content that bridges the gap between fundamental theories and professional practice. This research is supported by the Institute for Human Sciences (IWM) under the Documenting Ukraine grant. This research proposes an integrated approach to modernize environmental education, specifically through the development of an interdisciplinary "Water Security" course designed for Master's students. The study's objective was to create an effective didactic system that systematizes knowledge of natural-science theories while addressing urgent global issues such as climate change, water monitoring, and sustainable development. The "Water Security" course serves as a primary example of this model, integrating international practices, water policy, and environmental management into a cohesive module. The curriculum focuses on the co-evolutionary development of human society and nature, emphasizing the environmental imperative and professional responsibility for water resources. The methodology employed was comprehensive, including component analysis of ecological knowledge, postoperative analysis of subject skills, and educational experiments. To evaluate the effectiveness of the training, mathematical statistics were used to calculate the acquisition coefficient of knowledge. The study involved three years of experimental validation, demonstrating high didactic effectiveness. Results showed that students achieved an average knowledge acquisition coefficient of 0.85, significantly exceeding the satisfactory threshold of 0.60. The integrated approach was implemented across three distinct levels: internal disciplinary integration, interdisciplinary connections, and the highest level of methodological synthesis. In conclusion, the integrated approach to "Water Security" not only improves the quality of professional training but also fosters a co-evolutionary worldview and environmental responsibility. This model effectively extrapolates modern scientific developments into curricula, helping students master complex dimensions of environmental policy and international legal frameworks. Future research will focus on improving assessment methodologies for these integrated modules and refining the theoretical provisions of content integration to ensure the continuity of educational objectives.

Keywords: *Water security, integrated approach, sustainable development, environmental education, interdisciplinary learning.*

1. Introduction

The modernization of educational content as a strategic priority and a cornerstone of higher education reform was explicitly highlighted in the 2015 Yerevan Communiqué (which defined the enhancement of teaching and learning quality as the primary mission of the EHEA). This commitment was further solidified in the 2018 Paris Communiqué (stressing that the core mission of the Bologna Process involves structural reforms to ensure the relevance of teaching) and recently reaffirmed by the 2020 Rome Communiqué. The latter specifically introduced the "Recommendations to National Authorities for the Enhancement of Higher Education Learning and Teaching in the EHEA" (Ministerial Conference Yerevan, 2015; Ministerial Conference Paris, 2018; Rome Ministerial Communiqué, 2020).

Aligning with the priorities of the Rome Communiqué and subsequent national support guidelines, Ukrainian higher education institutions are tasked with refining teaching and learning methodologies. This transformation focuses on student-centered and competence-based models, emphasizing innovation, structured stakeholder engagement, and the integration of empirical and scientific research findings (Rome Ministerial Communiqué, 2020). Establishing a methodology for content formation remains a sophisticated

challenge (Cheung & Slavin, 2016; Stensaker & Fumasoli, 2017; Kosmutzky & Nokkala, 2020, etc.). Fundamentally, educational content represents a structured system of scientific knowledge, practical competencies, and ethical-aesthetic values that must be internalized during the pedagogical process (Mitryasova 2020).

The objective factors steering the evolution of educational content include:

- **The advancement of science and technology**, which introduces novel theoretical frameworks and radical technological shifts. For instance, the curriculum for natural sciences has undergone significant changes to incorporate developments in molecular biology, genetic engineering, and green chemistry.
- **Modern societal demands** regarding the preparation of the next generation (defining the necessary professional profile and personal attributes).
- **State policy directions** and national strategic goals.

The historical trajectory of differentiation and integration suggests that science itself has developed mechanisms to transcend the constraints of narrow disciplinary boundaries. This alternative is known as the integrated or interdisciplinary approach. The synthesis of scientific knowledge occurs through various modalities—from adopting concepts and methods across disciplines to the emergence of the systems method in the 20th century (An Integrated Approach to Learning, Teaching & Assessment, 2017). Today, the latter is particularly vital as it enables the analysis of objects and phenomena in their holistic interconnectedness.

Consequently, integration stands as a dominant trend in scientific development. These integration processes manifest through: the organization of research at the intersection of related fields; the creation of universal scientific methods; the pursuit of unifying theories (such as the "Grand Unification" in physics or global evolutionary synthesis in biology and chemistry); and the development of meta-methodological theories like cybernetics or synergetics. Furthermore, contemporary scientific challenges have become increasingly complex, requiring multi-disciplinary cooperation, particularly in addressing environmental crises (Ampatzidis & Ergazaki, 2017, 2018; Little & Green, 2009; Menashy & Verger, 2019).

Ukraine's integration into the European Higher Education Area and its adherence to the Bologna Process necessitate a fundamental update of educational content and philosophy. The culture of the 21st century is moving away from fragmented sectoral thinking toward an integrated paradigm, where professionals must be innovation-oriented and focused on human and societal values. The current educational philosophy promotes systemic pluralism, conceptual dialogue, and the mutual enrichment of different perspectives, offering vast opportunities for both educators and students. Therefore, universities are challenged to train a new generation capable of meeting modern requirements. Natural science education, in particular, holds immense potential for addressing sustainable development and environmental issues. Its content is increasingly focused on integrated courses and innovative knowledge structures for a holistic understanding of the world (Munawaroh, 2017). Thus, the current research focus lies in reorienting curricula and implementing issues through an integrated lens (Mitryasova, 2020). As a practical application of this approach for understanding sustainable development, we have developed an interdisciplinary training course.

2. Objectives

The primary goal of this study is to develop an effective didactic system based on an integrated approach to natural science education. This is operationalized through the design of a "Water Security" course, which places a significant emphasis on professional orientation and career-readiness for future specialists.

The **object** of this study is the content of natural science education within the framework of the professional preparation process, specifically focusing on the academic training of students enrolled in environmental specialties.

The **subject** of this research is the specific curricular content and structure of the interdisciplinary course on water security, tailored for university students majoring in environmental sciences.

3. Methods

Using partial scientific methods (component analysis of ecological knowledge, postoperative analysis of subject skills, etc.), general scientific methods (educational experiment, etc.), organizational, empirical, and methods of mathematical statistics determined the principles of selection of educational material, created the content of integrated training course, staging an educational experiment, summarized its results and analyzed the data.

To evaluate the completeness of students' knowledge and skills were defined by the ratio of the notions number of applied by students to the number of definitions that can be used. The tasks consisted of

their reproductive level of educational material. The quantitative characteristic of the completeness of the knowledge factor was the acquisition coefficient of knowledge by students. The formula 1 (Mitryasova, 2020) used for this:

$$\overline{K} = \frac{\sum N_i}{n\sum N} \times 100\%, \text{ where} \quad (1)$$

n – the total number of students who performed work;
$\sum N$ – the number of correct answers in the test;
$\sum N_i$ – the number of correct answers of students.

4. Discussion

This research project has integrated into the interdisciplinary European studies curriculum at Petro Mohyla Black Sea National University. The central outcome of this initiative is the development of a robust didactic system designed to impart interdisciplinary knowledge in natural science, specifically applied through a specialized course on water security.

The study defines and substantiates the core principles and thematic directions of an integrated approach tailored for the education of environmental science students. At the heart of this approach lies a set of foundational criteria for selecting and structuring educational material. These include systematization, where the goals of natural education are aligned with leading scientific laws, theories, and categorical concepts, as well as the principle of interdisciplinary connectivity. Furthermore, the content is driven by fundamentalization and a strong professional orientation, ensuring that the curriculum remains focused on critical global challenges such as climate change, sustainable development, and the current ecological status of water resources (Bezsonov et al., 2017; Mitryasova & Pohrebennyk, 2020).

In this context, the integrated approach is viewed as a specialized method of content design. It moves beyond simple knowledge transfer to create a system of interdisciplinary communications that coordinates and unifies basic categories into a modern natural-science picture of the world. This integration is implemented across three distinct levels: the intradisciplinary and interdisciplinary levels, which focus on selecting facts and methods according to specialization, and the highest level—methodological synthesis. At this superior level, students engage with dialectic categories such as system, structure, causality, and consequence, allowing for a deeper philosophical understanding of environmental processes.

The practical application of this methodology is found in a Master's level course in Environmental Science. This curriculum addresses pivotal topics, including water resource management, water quality standards, and the legal aspects of water policy. A primary focus of the training is the exploration of European practices in water security. The course content is intentionally constructed around the core tenets of sustainable development, emphasizing the necessity of integrated knowledge for making optimal management decisions.

By grounding the curriculum in the environmental imperative and the co-evolutionary development of society and nature, the course addresses urgent issues of pollution and climate change (Mitryasova et al., 2017). Ultimately, this narrative-driven approach allows students to effectively trace the evolution of integrated water and environmental management within the European Union, thereby fostering a sophisticated awareness of European standards and global environmental responsibility.

The training course is constructed upon a robust interdisciplinary foundation, synthesizing key elements of sustainable development strategies with the extensive European experience in environmental water policy (Mitryasova, Koszelnik et al., 2020; Mitryasova & Pohrebennyk, 2020). Its scope is comprehensive, addressing vital thematic areas such as water resource management, climate change impacts, monitoring protocols, and pollution control. Furthermore, the curriculum explores water quality standards, advanced purification techniques, and the nuances of European policy practices. As a truly interdisciplinary endeavor, the course emphasizes the vital integration of environmental requirements into broader policy sectors. It also incorporates an international dimension, examining the European Union's influential role in global initiatives—including the Kyoto Protocol and the UNESCO Roadmap for Education for Sustainable Development—and its collaboration with the International Water Security Network.

Beyond theoretical frameworks, the course bridges the gap between policy and practical tools for water management. It specifically contrasts and aligns the practices of the EU and Ukraine regarding water quality, biodiversity conservation, and fisheries, highlighting the progressive integration of these sectors into a unified management system.

Upon successful completion of the course, students are expected to achieve a high level of professional and analytical competence. Specifically, they will be able to:

- Discern the differences between EU and Ukrainian policy instruments for water monitoring while explaining the hierarchical goals of management at national, regional, and global levels.
- Articulate the evolution of systems and ecosystem thinking, applying these paradigms to the ongoing development of integrated environmental management.
- Identify and address key ecological threats to water security using precise, up-to-date professional terminology.
- Navigate and apply information from multilateral environmental agreements and EU-specific policy frameworks to research and practical problem-solving.
- Demonstrate knowledge of advanced monitoring methods, innovative water technologies, and the intricate links between water quality, public health, and research development.
- Conduct sophisticated synthesis and creative reflection on diverse information sources, enabling them to discuss the progressive integration of biodiversity and resource management within the industrial and corporate sectors (Table 1).

Table 1. International and European Dimensions of the Water Security Course.

Dimension	Key Instruments and Frameworks	Focus Areas
Global / International	Kyoto Protocol, UNESCO Roadmap (ESD), Sustainable Development Goals (SDGs)	Climate change mitigation, global education for sustainability, and water security networks.
European Union (EU)	EU Water Framework Directive, European Green Deal, EU Biodiversity Strategy	Integration of environmental requirements into sectoral policies, water quality standards, and monitoring tools.
Bilateral (EU-Ukraine)	Association Agreement, progressive integration of practices	Harmonization of Ukrainian water management with EU practices in fisheries, biodiversity, and resource control.

The pedagogical experiment, conducted without control groups due to the unique curriculum, confirmed high-quality knowledge acquisition with an average completeness coefficient of 0.85 and a remarkably low forgetfulness rate of 3–5% two weeks post-course. Beyond these quantitative metrics, the formative process fostered increased student engagement, stronger research motivation, and a greater capacity for original reflection on complex environmental problems.

5. Conclusions

The developed didactic system, based on an integrated approach, has demonstrated high efficiency in structuring natural science education. By defining clear principles for content selection and implementation levels, the study proved the effectiveness of this model through the “Water Security” course. This interdisciplinary curriculum successfully bridges environmental policy and management tools, aligning EU and Ukrainian practices regarding water quality, biodiversity, and resource management. Quantitative analysis confirmed successful knowledge acquisition, with students achieving a high average completeness coefficient of 0.85. The integrated approach reflects modern scientific evolution and remains highly relevant for fostering a deep understanding of sustainable development. Future research will focus on refining the theoretical and practical frameworks of integrated natural science courses and enhancing methodologies for assessing student performance within these complex educational models.

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RETHINKING SPACE TO RETHINK LEARNING: DESIGNING INCLUSIVE SCHOOLS FOR ALL

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Abstract

Research increasingly shows that learning environments shape participation, engagement and well-being, and that inclusion requires more than removing architectural barriers. Building on this evidence, INDIRE has advanced a view of the school as an integrated and permeable learning environment, formalised in the 1+4 Manifesto "Spaces for a New Generation of School in Italy" and subsequent studies. Grounded in Universal Design for Learning and the WHO ICF bio-psycho-social model, the framework links spatial configurations to teaching strategies and to learners' diverse functioning profiles. To support teachers' reflective planning, INDIRE developed a digital application that helps identify environmental facilitators and barriers and align space, pedagogy and student needs. Pilots in professional development contexts show the tool supports self-evaluation and guides design choices that strengthen equity and participation

Keywords: *Inclusion, learning environments, equity, teaching-learning activities.*

1. Learning spaces and inclusive learning processes: An ICF-informed perspective

Educational research has increasingly converged on the understanding that physical learning spaces play a decisive role in shaping learners' functioning, understood as the dynamic interaction between individual characteristics, educational activities, and environmental conditions (Barrett, 2015; Scott-Webber, 2004; Higgins et al., 2005; Manninen et al., 2007; Brooks, 2011, 2012). From an ICF perspective (WHO, 2001), learning environments are not neutral backdrops for instruction, but environmental factors that directly influence students' levels of activity and participation, as well as their well-being, motivation, and engagement (D'Alonzo, 2019). In this sense, the organization, flexibility, material configuration, and symbolic meaning of space contribute to either facilitating or restricting educational participation, depending on how they interact with learners' diverse profiles of functioning (Gennari, 1988; Cleveland, 2009). Building on this conceptual framework, INDIRE's long-term research on Innovative Learning Environments (ILEs) has progressively reframed school space as a pedagogical, organizational, and cultural device that actively mediates learning processes (Infante, Moscato, & Panzavolta, 2023). In continuity with the Manifesto 1+4 Educational Spaces for the New Millennium (INDIRE), the school is conceived as a system of interconnected environments—formal and informal, individual and collective, exploratory and reflective—each associated with specific configurations of activity, interaction, and participation (Carro & Tosi, 2023). Within an ICF-informed approach, these environments are interpreted as potential facilitators or barriers, depending on the extent to which spatial layouts, furnishings, technologies, and learning situations support autonomy, interaction, accessibility, and meaningful engagement for all students (Vanacore & Gomez Paloma, 2020).

More recent developments in INDIRE's research explicitly foreground the inclusive value of learning spaces by moving beyond a narrow focus on accessibility or the mere removal of architectural barriers. Inclusion is conceptualized as a systemic property of educational contexts, emerging from the alignment between spatial design, didactic practices, and organizational choices (Castoldi, 2020). Empirical studies and professional development initiatives promoted by INDIRE show that inclusive ILEs are not designed for specific categories of learners but aim to create sufficiently enabling conditions for the widest possible range of functioning profiles, in line with the principles of UDL (Meyer, Rose, & Gordon, 2014). Flexibility, usability, clarity of spatial affordances, and the possibility of multiple configurations emerge as key environmental features that enhance participation, self-regulation, collaboration, and well-being (Brooks, 2012; Higgins et al., 2005). From this perspective, learning environments operate as active facilitators of functioning, contributing to a cultural shift in which diversity is recognized as an ordinary dimension of educational life and inclusion is embedded within everyday pedagogical practices rather than addressed through compensatory or exceptional interventions.

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2. Inclusive learning spaces

Since the early 2010s, INDIRE has progressively developed a coherent line of inquiry on learning environments, framing space as a key driver of pedagogical innovation and of flexible, personalised teaching practices (Tosi, 2019). Central to this perspective is the idea that learning cannot be confined to the traditional classroom alone: educational processes unfold across a variety of settings that should be intentionally designed to respond to evolving learners and to the complexity of contemporary society. This approach challenges the spatial model inherited from early twentieth-century mass schooling, largely based on standardised classrooms and transmissive pedagogies. INDIRE's research highlights the role of space in shaping how learning occurs and in creating the conditions for learning to be meaningful (Atkin, 2011), deep (Fullan, Quinn, & McEachen, 2018) and student-centred (Crumly, Dietz, & D'Angelo, 2014). The configuration of spaces—together with furniture, materials and technologies—functions as a set of affordances (Gibson, 1979) that influences the meanings students construct through learning experiences (Young, Cleveland, & Imms, 2020). Learning environments designed around functional and symbolic values (INDIRE, 2016) support diverse learning styles and enable teachers to plan activities that balance individual, collaborative, informal, exploratory and community-oriented experiences. Beyond safety requirements, spatial quality affects well-being, behaviour and learning: poorly lit, overcrowded, noisy or thermally uncomfortable environments can increase stress and reduce attention, often disproportionately affecting learners who require additional support.

This conceptual shift is synthesised in the Manifesto "1+4 Learning Spaces for a New Generation of School in Italy", which proposes a school articulated into five interconnected environments. Each space is conceived in relation to specific pedagogical intentions, phases of learning, class organisation and students' diverse profiles, including interests, abilities and vulnerabilities. At the core lies the group learning space, which reinterprets and expands the traditional classroom. Rather than a fixed and uniform setting, it is designed to support collaborative practices and multiple forms of interaction, overcoming the rigid layout of desks in rows that historically reinforced teacher-centred instruction.

Over time, INDIRE's research has further strengthened the link between learning environments and inclusive education, drawing on the bio-psycho-social model of the WHO ICF framework (WHO, 2007; Caprino et al., 2022). Within this lens, space is understood as a contextual factor that can enable or hinder participation. Consequently, the Manifesto has been progressively elaborated to include concrete guidelines and design principles aimed at fostering inclusion through spatial organisation and use (Infante et al., 2023). In this perspective, the group learning space must ensure physical comfort—appropriate lighting, ventilation, thermal regulation, acoustic quality and clear signage—while allowing flexible configurations that support cooperative work and broad participation. Adaptability and spatial legibility are key features that help students engage meaningfully according to individual needs.

Alongside this, the individual space is designed to support autonomy, concentration and self-regulation. By limiting sensory overload and offering protected, calm settings, it responds to learners who benefit from quieter environments for reflection and focused activity, contributing to overall mental well-being. The Agora embodies the school's openness to the wider community: as a shared and representative space, it supports communication, collective identity and social belonging, and requires accessibility and effective wayfinding so that all users can navigate independently and feel recognised within it. Informal spaces play a complementary role by supporting spontaneous interaction, peer exchange and informal learning; their inclusiveness relies on being easily identifiable and usable, enriched by graphic, tactile, digital and analog supports that facilitate expression and communication without mediation. Finally, the exploration lab is dedicated to hands-on, experiential learning. Equipped with tools, materials and technologies—including digital and immersive resources - it enables differentiated and personalised approaches and encourages students to move autonomously, explore phenomena and develop talents in line with UDL principles (CAST, 2011).

To support teachers in translating these principles into everyday practice, INDIRE has developed an online application designed to guide the design and arrangement of inclusive and innovative learning environments. Grounded in the ICF bio-psycho-social model, the tool helps teachers reflect on how environmental factors can act as facilitators or barriers to learning and participation. It enables teachers to identify and configure teaching-learning settings in relation to the educational needs of individual students and the class group as a whole. By connecting pedagogical intentions, activity types and learners' functional profiles, the application supports informed decisions about spatial organisation and promotes a proactive, non-categorical approach to inclusion-encouraging flexible environments responsive to diversity rather than solutions tailored to specific diagnoses. Overall, the application acts as a practical bridge between research and practice, empowering teachers to use space as a pedagogical resource and to create learning environments that foster participation, autonomy and well-being for all learners.

3. The INDIRE ICF-based questionnaire

The INDIRE ICF-based questionnaire is a digital and methodological tool designed to support schools in the systematic analysis, documentation, and redesign of teaching practices and learning environments from an inclusive and ecological perspective. Structurally, the questionnaire is organized into six sections aligned with key ICF domains that are particularly relevant to the school context: learning and applying knowledge, general tasks and demands, communication, mobility, self-care, and interpersonal interactions and relationships. This structure allows teachers to explore how didactic activities, spatial configurations, organizational arrangements, and relational dynamics interact with students' functioning, participation, and well-being within everyday school life. The main objective of the questionnaire is not summative evaluation, but professional guidance and transformation. It is conceived as a reflective device that helps teachers identify whether specific activities and spaces function as facilitators or barriers to inclusion. Once completed, the questionnaire generates a radar chart that highlights teaching activities that are more or less suited to the student's needs, both to better enhance their abilities and to minimize their effort and difficulties. Interpreting the results is crucial: a score between 0 and 1 indicates an appropriate activity, whereas a score between 0 and −6 signals a potentially harmful activity that may lead to student isolation. As shown below (Figure 1), the INDIRE ICF-based questionnaire suggests the most appropriate tasks to personalize learning (i.e., peer-to-peer activities, game-based learning, small-group tasks etc.) while showing that other ones are less adequate (i.e., lecturing, discussion, etc.).

Figure 1. Rendering of the INDIRE ICF-based questionnaire.

Teaching situations	Average score
Lecture	0.45
Individual study	0.84
Game-based activity	0.94
Mentoring	0.94
Peer-to-peer learning	0.87
Hands-on activities	0.84
Small group work	0.87
Discussion	0.48
Presentation	0.52

By making these dynamics visible through structured observation, the questionnaire supports a process of informed redesign of both teaching strategies and learning environments. The underlying logic is cyclical and action-oriented: data collection leads to interpretation, which in turn informs the rethinking of activities, methods, and spatial use. One of the key strengths of the INDIRE questionnaire lies in its flexibility and scalability. It can be administered for individual students, small groups, or entire classes, making it suitable not only for students with certified special educational needs, but also for fragile learners and high-achieving students. This broad applicability reinforces a universal approach to inclusion, moving beyond compensatory logics toward proactive design for all. Moreover, the tool encourages collaboration among teachers, acting as a shared reference point between subject teachers and support teachers and fostering a common professional language grounded in the ICF framework.

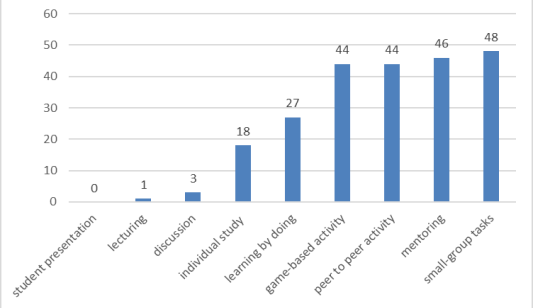
The questionnaire automatically generates visual and numerical outputs, such as radar charts, which offer immediate and intuitive feedback on the inclusiveness of proposed activities. These visualizations help teachers quickly identify areas of strength and critical issues, supporting clearer decision-making and deeper pedagogical reflection. An additional advantage is the possibility to export results in PDF format, allowing their integration into official school documentation such as Individualized Education Plans (PEI) and Personalized Learning Plans (PDP). In this sense, the questionnaire also functions as a concrete support tool for observation, documentation, and justification of instructional choices. Overall, the INDIRE questionnaire represents a bridge between theory and practice, observation and action. By embedding the ICF framework into everyday teaching and spatial planning, it promotes a pedagogy in which learning environments are no longer neutral settings, but active agents in inclusion and learning. Through its structured yet flexible design, the tool empowers teaching teams to move toward more intentional, collaborative, and inclusive educational practices.

4. Preliminary results

The questionnaire was tested in two online professional development contexts aimed at supporting reflection on the relationship between pedagogy, architecture, and inclusion, as well as at providing

operational guidance to participating teachers. Data collection began in 2022 within a training course on inclusive learning spaces jointly organized by the Regional School Office and INDIRE. The results allowed teachers, working individually or in small groups, to gain an initial overview of facilitating and hindering teaching situations in relation to different learning contexts and individual needs. The outcomes of each compilation (Fig. 1) subsequently guided participants, in the following phases of the course, in the design of inclusive teaching situations and learning settings, challenging the notion of the support classroom as the primary space for individualized interventions. The analysis of the 50 completed design projects shows that the most frequently proposed teaching situations are also those considered the most inclusive: small-group tasks, mentoring and peer-to-peer activities, together with game-based learning, in line with the findings reported by Mitchell (2014).

Figure 2. The most common teaching situations.



In 2025, the questionnaire was used within a training course for prospective support teachers at the lower secondary school level. During the training activities, participants were invited to use the application (on a voluntary basis) to initiate reflection on the relationship between the configuration of learning environments and teaching situations connected to the needs identified through completion of the tool. A total of 43 complete questionnaires were collected, from which several elements emerged, highlighting how the questionnaire can serve as a starting point for a broader reflection on the relationship between learning environments, spatial arrangements, and the selection of teaching situations best suited to increasing class participation and supporting teachers in reflecting on spatial configurations aligned with specific types of activities. The application's ability to maintain a holistic view of the learner -considering strengths and areas of difficulty - enables the identification of functional and contextual educational needs that cut across cognitive, relational, and behavioural dimensions. Rather than focusing on individual diagnoses, the tool promotes an interpretation of needs at both the individual and class-group levels, reinforcing the role of learning environments as key facilitators of participation. The recurring attention to dimensions such as attention regulation, interaction, and communication confirms the relevance of spatial and organizational settings in inclusive design, positioning the application as an effective bridge between the ICF framework and everyday pedagogical practice. With regard to the collected data, the compilations show that domains related to learning and relationships are frequently described as areas requiring support, even when reported difficulties are mild or moderate. In the domain *Learning and Applying Knowledge*, approximately 30% of the compilations indicate no significant difficulty, while a further 30% report mild (16.4%) or moderate (13.7%) levels of difficulty. This distribution suggests that many needs are situational rather than severe, reinforcing the importance of interventions targeting environmental and organizational factors rather than exclusively individual or remedial actions.

Even more indicative are the results related to the domain *Interactions and Interpersonal Relationships*. In this area, over one third of the compilations report mild (19.2%) or moderate (15.1%) difficulties, while only a smaller proportion indicates more severe challenges. These findings highlight the centrality of relational, behavioural, and regulatory aspects in everyday classroom dynamics, confirming that inclusive processes are strongly linked to how learning environments support interaction, participation, and social engagement. Overall, the prevalence of mild and moderate profiles across domains supports the pedagogical value of the application's approach: rather than addressing isolated or exceptional cases, the tool helps teachers interpret diffuse and emerging needs at both individual and class-group levels.

5. Conclusions, limits and perspectives

The results show that the application effectively supports teachers in identifying functional and contextual educational needs that extend across cognitive, relational, and behavioural domains. The prevalence of mild and moderate difficulties highlights the situational nature of many needs, emphasizing the role of learning environments as key facilitators of participation rather than focusing on individual remediation. Data related to interaction, communication, and attention regulation confirm the centrality of

spatial and organizational settings in inclusive design. The findings suggest that the tool promotes a shift from individualized support spaces toward flexible and shared learning settings. Overall, the application emerges as a valuable bridge between the ICF framework and everyday pedagogical practice, with potential for broader implementation

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FOSTERING POSITIVE ATTITUDES TOWARD ENGLISH LEARNING: A JAPANESE SCHOOL CASE USING "SMALL TALK" AND INTERNATIONAL UNDERSTANDING

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Abstract

The early introduction and formalization of English education in elementary schools have made the transition between elementary and junior high school a critical issue. While the introduction of foreign language activities in elementary schools has improved students' English proficiency and reduced resistance to learning English, the number of children who dislike English has been increasing. Factors cited for this include insufficient coordination between elementary and junior high schools, increased difficulty in content, and teaching methods. At the elementary level, the goal is to cultivate the foundational qualities and abilities for communication, and language activities are essential for achieving this. It is hypothesized that the effective utilization of Small Talk from an intercultural perspective can help children experience the joy of communication, thereby sustaining or enhancing their motivation for English learning and fostering their interest in cross-cultural understanding. This presentation reports on the findings from an inquiry into how a year-long focus on Small Talk instruction at Elementary School A influenced children's perceptions and learning motivation. Using the classroom practices at Elementary School A, where English aversion is low, as a case study, we clarify how children's positive attitudes toward English learning are sustained through a year of classroom observation, student questionnaires, and interviews with the teaching staffs. This study examines classroom features that foster positive engagement in English language learning among Japanese elementary school students, with a particular focus on Small Talk and international understanding. The lessons are characterized by innovative use of Small Talk and dynamic progression. Multiple instances of Small Talk are conducted with assistant language teachers (ALTs) during each class session—including introductions, pre-activity demonstrations, and mid-lesson guidance—creating an environment in which children naturally become familiar with English expressions. Instructors primarily use Classroom English, employing simple language supported by concrete objects and gestures to minimize Japanese usage. This approach cultivates students' ability to infer meaning from purpose, context, and situation. Instructional formats appropriately combine whole-class, individual, and collaborative learning to deliver personalized guidance. Additionally, ICT tools such as tablets and digital textbooks are partially and effectively utilized to visualize learning and provide interactive experiences designed to spark children's interest. Abundant opportunities for language activities and performances in pairs or groups are provided, with JTEs and ALTs actively engaging in communication tasks and offering positive feedback. The lesson design also incorporates perspectives on cross-cultural and international understanding, contributing to the development of students' global awareness and communicative competence.

Keywords: *Small talk, international understanding, Japanese elementary school, English education.*

1. Introduction

1.1. Background

In 2020, a new course of study was implemented, introducing foreign language activities in grades 3 and 4 and formal English education in grades 5 and 6. This early introduction has made the transition from elementary to junior high school a critical issue. Although foreign language learning in elementary schools has improved proficiency and reduced resistance, the number of children who dislike English has continued to rise, due in part to insufficient coordination between school levels, increased difficulty, and instructional methods (MEXT, 2024). National surveys show that the percentage of students who dislike English increased from 23.7% in 2013 to 31.5% in 2021, and disparities in English mastery have emerged depending on access to cram schools (Toyo Keizai, 2025). Interest in English also tends to diverge in the upper grades, with only about 60% of 6th graders reporting that they like English (Benesse, 2023). Meanwhile, junior high school students who actively engaged in language activities reported higher

achievement and more positive attitudes (MEXT/NIEP, 2024), suggesting that language activities are key to fostering interest and understanding. At the elementary level, the goal is to cultivate foundational communicative abilities, making meaningful language activities essential. In an EFL context such as Japan, it is particularly important to establish clear objectives, contexts, and opportunities for English use. Foreign language learning can also stimulate curiosity about the world and serve as a bridge to global awareness and intercultural understanding (Ishimori, 2019). Based on this perspective, this study hypothesizes that the effective use of "Small Talk," framed interculturally, enables children to experience the joy of communication and thereby sustains or enhances their motivation for English learning.

1.2. "Small talk"

In order to develop pupils' speaking skills, short oral interaction/conversations between teachers and pupils or among pupils themselves—namely, Small Talk—are recommended (MEXT, 2017). In English-speaking countries, "small talk" refers to a light conversation, chit-chat, or a casual talk about unimportant topics. However, in Japanese English education, it means short conversations designed to reinforce English expressions, and in most cases, it consists of two or three set phrases on a given theme. The primary objective of Small Talk is to strengthen previously learned expressions and to learn basic expressions or strategies necessary for continuing dialogue (MEXT, 2017). However, simply repeating the fixed phrases introduced in textbooks does not effectively foster communication skills.

2. Design

2.1. Hypothesis

This study is grounded in the following hypotheses. Language activities constitute a fundamental component in the development of communicative competence. For pupils at the initial stages of English learning, it is essential to engage in Small Talk as a foundational communicative tool. The continuous and effective implementation of such activities is expected to foster a sense of enjoyment in using English, thereby enhancing learners' motivation to study the language and cultivating interest in foreign cultures. Consequently, these practices may contribute to reducing negative attitudes toward English and mitigating feelings of aversion. Furthermore, as the previous research suggests (Cates, 2002; Ishimori, 2019), it is anticipated that the process of learning English will serve as a gateway to intercultural understanding, evoking curiosity and a sense of pleasure in exploring diverse cultural perspectives.

2.2. Objective

Elementary School A, a mid-sized public school in rural northern Japan, shows a notably low level of aversion to English compared with national and prefectural averages. In the 2024 National Academic Achievement Survey, 69.3% of sixth graders nationwide and 67.3% in the prefecture reported that they "like" or "rather like" English, whereas 75.5% of students at Elementary School A expressed positive attitudes. This outcome is presumed to reflect the school's emphasis on Small Talk since the 2023 academic year. Building on this context, the present study uses Elementary School A as a case study to examine how positive attitudes toward English—including interest in foreign cultures and global issues—are cultivated. Specifically, it explores the background of this situation and identifies educational factors that help prevent the development of negative attitudes toward English.

3. Methods

This study reports findings from an inquiry into how a year-long emphasis on Small Talk instruction at Elementary School A influenced pupils' perceptions and learning motivation. The classroom practices at Elementary School A, where aversion to English is relatively low, are employed as a case study to elucidate how pupils' positive attitudes toward English learning are sustained. Evidence is drawn from a year of classroom observation, student questionnaires, and interviews with teaching staff.

(1) Survey target, period, and procedures:

The survey was conducted with four sixth-grade classes (115 students in total) at a medium-sized public elementary school in northern Japan (School A). The survey period encompassed one academic year, from April 2024 to March 2025. At the time of the study, School A employed a Japanese Teacher of English (JTE), aged 29, and an Assistant Language Teacher (ALT) from the United States, aged 33. These teachers had been engaged in team-teaching (TT) for grades 3 through 6 since 2021. Beginning in the previous academic year (2023), the teachers collaborated with the researcher to enrich language activities with a particular emphasis on Small Talk. With the consent of School A, non-participatory classroom observations were systematically conducted throughout the survey period, maintaining an objective stance while collecting data on instructional practices and learner engagement. Specifically, the Small Talk conducted

by the two teachers was video-recorded and transcribed, while pupils's reactions and spontaneous utterances were documented during classroom observations in order to accumulate qualitative data. Student questionnaires were also conducted, furthermore, post-classroom research discussions were held once or twice per month to accumulate additional insights into the teaching and learning processes. All data collection procedures adhered to ethical guidelines and ensured the protection of personal information.

(2) Methods:

In addition to classroom observations conducted throughout the 2024 school year, qualitative and quantitative data were collected through multiple instruments. Student questionnaires were administered three times (July, December, and March) via Google Forms, and the results informed subsequent reflections and discussions. Based on these findings, interviews were conducted with the JTE three times (January, February, and April 2025) and with the ALT twice (January and February 2025) to gather their interpretations, instructional approaches, and perceptions of pupils' learning attitudes. Together with classroom observations and post-lesson discussions, these interviews provided triangulated data for examining the educational factors that sustain positive attitudes toward English learning.

4. Classroom practice

4.1. Overview (features of the lesson)

This study examines classroom features that foster positive engagement in English language learning among Japanese elementary school students, with particular emphasis on Small Talk and international understanding. Multiple instances of Small Talk are conducted by the JTE and ALT during each class session—including introductions, pre-activity demonstrations, and mid-lesson guidance—thereby creating an environment in which pupils naturally become familiar with English expressions. The teachers primarily employ simple forms of "Classroom English," using accessible language supported by concrete objects and gestures to minimize reliance on Japanese. This approach cultivates students' ability to infer meaning from purpose, context, and situation. Instructional formats combine whole-class, individual, and collaborative learning in ways that allow for personalized guidance. In addition, ICT tools such as tablets and digital textbooks are partially and effectively utilized to visualize learning and provide interactive experiences designed to stimulate pupils' interest. In the observed classes, abundant opportunities for language activities and performances in pairs or groups were provided, with the JTE and ALT actively engaging in communication tasks and offering positive feedback to pupils. The lesson design also incorporates perspectives on cross-cultural and international understanding, thereby contributing to the development of students' global awareness and communicative competence.

4.2. Examples of small talk

An illustrative example of "Small Talk" conducted during the lessons is presented below.

Table 1. Small Talk to encourage motivation to take action from familiarity with the target expression and raising global awareness (Note: ALT's name is Mark. "sensei" in Japanese means "teacher").

JTE:	What animal do you want to study?
ALT:	I want to study bears. Bears live in the forest. Forest loss is a big problem.
JTE:	What can you do?
ALT:	I can reduce paper. I use bamboo items. Please look at these. *(The ALT displays bamboo balls, spoons, and other items brought from home, taking them out of a bag and showing them to the pupils.)* I use these items at home every day. Using bamboo is more sustainable.
JTE:	(*Toward the pupils*) Why Mark sensei uses bamboo items? Not wooden items?
Ss:	*(Activities: Exchange of opinions among pupils)*
S1:	global warming *(in Japanese)*
JTE:	Global warming! Global warming is a big problem.
ALT:	Using bamboo items, trees cannot get cut. How about you? What animal do you want to research?
JTE:	I want to research tuna. We enjoy tuna sushi, sashimi and so on but overfishing is a big problem. *(While showing slides to the pupils)* Please look at this picture. Do you know this?
Ss:	Ehomaki!
JTE:	Yes. People who have eaten *(in Japanese)* , raise your hands! Please look at this picture. (*While showing a slide image of a large amount of Ehomaki being thrown away*) What's this?
Ss:	(Thrown away!) (MOTTAINAI!<What a waste!>) *(in Japanese)*
JTE:	Yes. Food loss. Food loss is a big problem. We can reduce food loss. Do you know 4 R? Please talk about 4R with your friends.
Ss:	*(Activities: Exchange of opinions among pupils)*
JTE:	*(While presenting the relevant part of the textbook)* Reduce, reuse, recycle and refuse. Mark sensei, what is "refuse"?
ALT:	Refuse is "no thank you!" *(using gesture)*

(Source) Created by the author based on class observation

What is notable in this lesson is the pupils' familiarity with target expressions (e.g., "XX is a big problem"), the effective use of real objects, and the teachers' prompts that stimulate thinking and highlight connections between environmental issues and daily life. The important expression was used naturally, enabling learners to internalize it within a communicative context. The ALT introduced bamboo tableware brought from home, explaining its sustainability and environmental benefits, while the JTE encouraged reflection through questions in English. Although students initially responded with a simple repetition of "global warming," the ALT supplemented by clarifying that using bamboo items prevents deforestation, thereby linking action to consequence. Through such supplementation and concrete examples, the lesson fostered logical reasoning and deeper comprehension.

This example illustrates that Small Talk extends beyond the fixed conversational patterns presented in textbooks. Rather than limiting practice to predetermined dialogues, it develops into a natural, comprehensible, and socially grounded form of interaction. Teachers and students collaboratively advance the conversation through questions and responses, thereby creating a new form of Small Talk. In other words, Small Talk is reconceptualized as a communicative tool. Furthermore, by introducing environmental issues, students are encouraged to think deeply while learning language. This serves as an exemplary case of how English learning can be meaningfully connected to real-world issues/themes, thereby demonstrating the potential of language education to foster global awareness.

4.3. How to use small talk

According to MEXT (2017a,b), Small Talk is prescribed to be conducted approximately once every two lessons as a routine activity for reviewing previously learned material. However, as demonstrated in the case of this school, Small Talk can be utilized in far more diverse ways as a communicative tool, extending beyond mere review to foster authentic interaction and engagement.

In the observed lessons, Small Talk was implemented regularly, occurring in every lesson approximately three to five times in various formats. Its use took diverse forms, including exchanges between the ALT and JTE, interactions involving the ALT/JTE and the whole class, dialogues with selected students, pair work among students, small-group discussions, and whole-class communication activities such as moving around the classroom. The functions of Small Talk were equally varied: greetings, the introduction of new units or topics, the presentation of new expressions, teacher demonstrations prior to student language activities, modeling and sharing goals before performance tests, reviewing, and providing guidance during student activities. Student pairs used it to confirm understanding and practice collaboratively, while groups and the entire class engaged in Small Talk as part of language activities that emphasized the enjoyment of authentic communication. In this way, Small Talk functioned as a bridge from mechanical practice to genuine language use, fostering engagement and communicative competence.

5. Results and discussion

5.1. Questionnaire results

Even as the study progressed and the content became more difficult, pupils' understanding remained around 95% throughout the year, and positive attitudes toward English stayed high. Even just before entering junior high school (March), only 4 of 115 students (3.5%) reported that they "somewhat disliked" English. Students also expressed a clear sense of progress, as reflected in comments such as, "I am beginning to understand the teachers' Small Talk (in English)."

5.2. Characteristics of the class

The class is characterized by unique and varied Small Talks that do not follow a pattern, and by the use of multiple Small Talks with ALTs in each class, introductions, demonstrations before language activities, mid-term instruction, etc., to create an environment where pupils naturally become familiar with English expression. Teachers employ Classroom English with simple expressions, objects, and gestures to reduce Japanese and enhance contextual inference. Their pedagogy combines simultaneous, individual, and cooperative learning to address diverse student needs. Also, tablets and digital textbooks are partially and effectively used to visualize learning, provide interactive learning experiences, and draw out students' interests. The school provides ample opportunities for pupils to engage in language activities and performances in pairs and groups, and JTE/ALTs are actively involved in communicative activities, providing positive feedback. The instructional design is noteworthy in that it incorporates the perspective of international understanding.

5.3. From the interview

Following the series of lessons, interviews were conducted with both the JTE and the ALT to examine how Small Talk was conceptualized and used in classroom practice. The JTE noted that

communication cannot be created through fixed textbook exchanges alone and that enriching Small Talk enhances language activities and facilitates feedback, which in turn builds students' confidence. The ALT similarly emphasized that relying solely on textbooks is unengaging, and that enjoyable Small Talk contributes to positive learning outcomes. These perspectives suggest that Small Talk, when implemented beyond fixed exchanges, fosters more meaningful language use, supports effective feedback, and enhances students' confidence and motivation by making English learning enjoyable and engaging.

6. Conclusion

6.1. Verification of the hypothesis

The findings of this study support the initial hypotheses. The sustained use of Small Talk as a communicative tool proved effective in fostering enjoyment in English language use among elementary school learners. Through continuous engagement in short yet meaningful interactions containing global messages, students demonstrated increased motivation to learn English and heightened interest in foreign cultures. The practice also contributed to reducing negative attitudes toward English, mitigating feelings of aversion. Furthermore, integrating Small Talk into classroom activities facilitated connections between English learning and broader intercultural understanding, reinforcing the perception of English as a gateway to global perspectives. Taken together, these results indicate that Small Talk can function not merely as a supplementary activity but as a pedagogically significant approach that enhances communicative competence and nurtures positive dispositions toward language learning.

6.2. Implication

As a result of one year of practical research, several distinctive features of these English lessons—beyond the role of Small Talk—were identified as contributing to the low level of aversion to English. First, continuous exposure to appropriately challenging English allowed students to experience partial difficulty followed by gradual understanding, stimulating curiosity and a sense of growth. Second, the lessons were learner-centered, encouraging active participation and positioning each child as an autonomous, dynamic participant. Third, the topics were closely connected to society, the wider world, and students' daily lives, fostering relevance, social utility, and awareness of global issues and intercultural understanding. Finally, the lessons created learning spaces independent of "teacher-talk," promoting self-determination, autonomy, responsibility, and self-management while enhancing enjoyment. Collectively, these characteristics illustrate how elementary English education can move beyond patterned practice to foster meaningful engagement, motivation, and positive attitudes toward language learning.

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AVENUE: EARLY FINDINGS FROM A PAN-EUROPEAN CENTRE OF VOCATIONAL EXCELLENCE ON EMERGING SKILLS IN THE CREATIVE VISUAL INDUSTRIES

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Abstract

Rapid technological change across the creative visual industries is increasingly misaligned with the update cycles of vocational education and training (VET). AVENUE is a four-year Erasmus+ Centres of Vocational Excellence initiative connecting five European ecosystems: animation, games, extended reality (XR), virtual production, and visual storytelling. This paper presents early findings from the first year of the project, which focused on establishing a repeatable evidence-to-action research loop. Using ecosystem-specific literature reviews, semi-structured interviews, and stakeholder consultations, the research identified converging skill patterns across sectors. These include the normalisation of hybrid technical-creative roles, a strong preference for short-cycle and modular upskilling formats, and the growing importance of transversal competences alongside software proficiency. As these findings represent an initial snapshot within a four-year programme, the paper also outlines forthcoming research and implementation phases through which insights will be iteratively tested via pilot training offers, micro-credentials, and curriculum adaptation.

Keywords: *Vocational excellence, creative visual industries, emerging skills, micro-credentials, modular learning paths.*

1. Introduction and background

The creative visual industries (e.g., video games, animation, extended reality, virtual production and visual story telling) are characteristic of persistent skill gaps, and saturated job markets (Hassreiter et al., 2024). These pressures are now compounded by rapid technological transformations driven by real-time technologies, immersive media, and increasingly data-driven production pipelines (StoryFutures Academy, 2023; XR4Europe, 2025). As such, game engines, virtual production workflows, XR platforms, and AI-assisted tools are no longer experimental but embedded in everyday professional practice.

While these developments expand creative and economic possibilities, they also challenge the capacity of vocational education and training (VET) systems to remain aligned with such rapidly evolving industry transformations. Consequently, industry tools and workflows change within months (Davies et al., 2025), however, the systemic review and accreditation cycles of educational programmes typically operate across multi-year cycles potentially widening the skill-gaps. This systemic mismatch, risks producing graduates whose skills could become outdated upon entry to the job market, thus exacerbating the skill gaps within creative visual industries. The AVENUE project aims to address this challenge by treating skills development not as a static curricular problem, but as a continuous alignment process between education, industry, and regional innovation ecosystems.

1.1. The AVENUE project

AVENUE is a four-year Erasmus+ Centres of Vocational Excellence (CoVE) initiative bringing together five European creative ecosystems: animation, games, extended reality, virtual production, and visual storytelling. The project aims to improve the responsiveness and relevance of the VET provision by embedding structured collaboration between education providers, industry partners, and researchers.

In its first year, AVENUE prioritised the design and validation of a repeatable “evidence-to-action” loop. This framework supports annual cycles in which emerging skill needs are identified, translated into educational interventions, and evaluated through practice-based feedback. A central premise of the project is that skills increasingly oscillate across creative sectors, making cross-ecosystem analyses essential for

understanding workforce development in contemporary production contexts.

Accordingly, this paper aims to synthesise skill needs within creative visual industry landscapes. We draw from sector-specific industry and academic publications, reflection reports from educational institutions (subsequently referred to as educational reports), and qualitative semi-structured interviews with industry experts to develop evidence-informed training programmes tailored towards upskilling the creative visual industry workforce.

2. Methodology and analysis framework

Informed by both academic and industry publications, each AVENUE ecosystem synthesised overviews of emerging skills and workforce development priority areas, in relation to technological changes. This desk-based research was supplemented by a series of 28 semi-structured interviews with industry professionals representing each AVENUE ecosystem, and educational reports produced by the project's educational partners (Avenue 1st Year Report, in preparation).

Interviews addressed the balance between technical and soft skill needs, perceived impacts of technological advances on workforce needs and the (mis/)alignment between educational provisions and industry needs. The educational reports provided overviews outlining the key challenges faced by the project's educational partners, and potential mitigation strategies in response to emerging skill gaps.

All data were thematically coded and triangulated across ecosystems. This identified converging patterns and near-term skill pressures across the five AVENUE ecosystems.

3. Findings

Despite differences in production culture and technological maturity, three consistent patterns were identified across all five ecosystems (Avenue 1st Year Report, in preparation).

3.1. Hybrid technical-creative roles

Across ecosystems, hybrid profiles combining technical competence with creative and production literacy were increasingly considered baseline rather than a niche requirement. Interviewees consistently emphasised that software proficiency alone was insufficient without an understanding of storytelling, pipeline dependencies, and collaborative workflows (Boutellier & Raptis, 2023).

For example, in virtual production (VP), roles such as VP supervisors and real-time technical directors have emerged as coordination points within productions spanning previously separate disciplines (Bennett et al., 2023). According to the AVENUE project's first year report (in preparation, 2026), interview data reinforced this pattern, with industry experts explaining that candidates need foundational 3D software understanding (for example), combined with capacities for rapid iteration though importantly, they "don't need to be the best" in any single area. This demonstrates the need for hybrid skill profiles encompassing technical proficiency alongside creative problem-solving abilities, without needing deep expertise in specific domains.

The games and XR ecosystems also demonstrated parallel shifts highlighting the industry's prioritisation of adaptable team players over exceptional individual performers (Hassreiter et al., 2024). Skill gaps were particularly noted with respect to the recruitment of artists combining creative, technical, and business awareness (Saluveer & Abay, 2025). Indeed, the XR ecosystem articulated this need explicitly by characterising the sector as "not by isolated technical specialisms, but by hybrid skill sets" (Avenue 1st Year Report, in preparation).

3.2. Preference for short-cycle and modular learning

Industry experts expressed preferences for short, task-oriented upskilling formats. Indeed, rapid iterations in tools and workflows reduces the perceived value of long training programmes, particularly for employed professionals. Therefore, modular learning units and micro-credentials were identified as effective mechanisms for addressing near-term skill gaps (CresCine, 2025). For example, the visual story telling ecosystem noted how the Institute of Art design + Technology, through their Creative Futures Academy partnership, offers over forty accredited micro-credentials, including certificates in Real-Time Virtual Production and Professional Skills for the Creative Industries (Avenue 1st Year Report, in preparation). The animation ecosystem research similarly recommended "improving flexible and agile curriculum frameworks" and "implementation of Micro Credentials" as key strategies. In games, the EGDF White Paper emphasises that "learning cannot stop at graduation" and that self-training currently dominates skill development, though often without adequate institutional support (EGDF, 2024).

3.3. Soft skills and transversal competences

Beyond technical skills, soft skills emerged as decisive for employability. For example, insights from the game's ecosystem demonstrated how nearly 74% of professionals ranked communication, collaboration, and resilience above software proficiency (Hassreiter & Thorning, 2025). AI literacy was also identified as a specific transversal competence across multiple ecosystems. For example, the animation ecosystem identified that AI "fundamentally changes how students approach cognitive work" and may leave them "less prepared for unexpected tasks that require independent judgement" (Avenue 1st Year Report, in preparation). Addressing this dependency, the XR ecosystem highlighted the importance of ethical awareness and policy literacy as emerging requirements, and familiarity with standards such as OpenXR and evolving accessibility requirements now embedded in professional practice (Avenue 1st Year Report, in preparation).

4. Discussion

These early findings support AVENUE's goal that skills development in the creative visual industries require flexible and adaptive educational structures. The normalisation of hybrid roles challenges disciplinary silos within VET, while demand for modular learning aligns with broader European discussions on lifelong learning and stackable qualifications (European Commission, 2024). The prevalence of hybrid profiles suggests that programme structures separating technology, business, and art into distinct tracks no longer align with industry requirements, hence universities must adopt holistic approaches combining these elements within integrated programmes (EGDF, 2024). There was preference for short-cycle learning challenges such as micro-credential validation within weeks rather than months traditional degree structures. However, effective implementation requires institutional adaptation and sustained industry partnership mechanisms.

5. Upcoming research and implementation phases

In the coming project years, AVENUE will translate these early findings into concrete educational actions, including pilot training programmes, micro-credential frameworks, and curriculum adaptations across partner institutions.

Year Two research (March-October 2026) will examine perceived relevance of tools and skills through structured surveys and collection of autobiographical accounts from professionals, educators, and students, addressing experiences of technological change and self-directed learning. Years Three and Four will track how identified patterns evolve and evaluate interventions developed in response to earlier findings, enabling refinement of the Oscillations framework and development of recommendations for institutions beyond the consortium.

6. Conclusions

This paper has presented early findings from the first year of the AVENUE project, highlighting converging skill patterns across five European creative ecosystems. The results underline the growing importance of hybrid technical-creative roles, modular learning formats, and transversal competences in contemporary production contexts.

These capabilities appear not as supplementary attributes but as integral requirements for effective practice in technologically complex, collaborative production environments. While preliminary, these findings validate AVENUE's core methodological premise: that continuous, evidence-based alignment between industry and VET is both necessary and achievable. Future project phases will extend this work through implementation and evaluation.

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LEARNING BY SOLVING AND SENSING: DATA-INFORMED PERSPECTIVES ON PROBLEM-BASED LEARNING

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Abstract

This study explores students' perceptions of the impact of PBL on their communication, collaboration, critical thinking, and motivation when applied in a blended learning context. PBL is grounded in the principle that learning occurs through the active resolution of authentic, real-world problems, thereby fostering critical thinking, collaboration, and autonomous learning. The research is based on quantitative data collected through a structured questionnaire consisting of two main sections: (1) perceived effects of PBL on different acquired skills, and (2) attitudes toward PBL compared with traditional teaching methods. The study involved 96 first-year students enrolled in 2023/24 academic year in a professional first-cycle programme at the Faculty of Public Administration, University of Ljubljana, in a blended English for Specific Purposes course. The Moodle Learning Management System (LMS) supported the PBL approach, while MS Teams facilitated group communication. The findings of this study contribute to the ongoing discourse on innovative teaching methodologies in language education and underscore the potential of PBL to bridge the gap between theoretical knowledge and practical application.

Keywords: *Problem-based learning, learning analytics, blended learning, higher education, student engagement.*

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1. Introduction

Problem-based learning (PBL) is a pedagogical approach that puts students at the center of the learning process. It encourages active engagement and collaboration, as well as the development of higher-order cognitive skills. Grounded in constructivist theory, PBL emphasizes active, student-centered learning through engagement with authentic problems. PBL promotes critical thinking, collaboration and self-directed learning, all of which are essential for professional success, yet are often underrepresented in traditional, lecture-based instruction (Barrows, 1996; Savery, 2006). In today's higher education landscape, integrating PBL into a blended learning environment that combines face-to-face interaction with digital learning platforms offers new opportunities for flexibility and personalization, as well as enabling continuous learning. It also facilitates constant monitoring and evaluation of students' engagement, motivation, and learning outcomes.

PBL offers significant advantages, primarily through its emphasis on problem-solving, teamwork, and self-directed learning, which are skills essential for success in professional contexts. However, these competencies are often marginalized within traditional educational systems that prioritize standardized assessments and are reluctant to adopt innovative teaching practices. By engaging learners in authentic, real-world challenges, PBL encourages active participation and responsibility for one's own learning process. A crucial starting point for developing collaborative and autonomous learning strategies is metacognitive awareness. This involves critically assessing one's cognitive processes, identifying personal strengths and weaknesses when approaching complex tasks, and taking effective action to accomplish learning objectives (Hmelo-Silver, 2004).

The transition from higher education to employment increasingly requires graduates to possess transferable skills that extend beyond their disciplinary expertise. PBL demonstrates a strong alignment with the competencies demanded in contemporary labour markets. Workplaces today emphasize skills such as critical thinking, effective communication, teamwork, adaptability and digital literacy, as well as domain-specific knowledge (OECD, 2018). Recent research confirms that employers increasingly value soft skills, such as teamwork, communication and adaptability, over purely technical expertise (Berkman, 2025).

In practice, problem-based learning (PBL) engages students in real-world problems, developing their critical thinking and innovative problem-solving skills. It also strengthens their teamwork, oral and written communication, and decision-making skills through collaborative tasks, presentations, and reflective discussions (Yu & Zin, 2023). Iterative feedback and self-assessment promote metacognitive awareness, self-regulation and confidence (Hmelo-Silver, 2004). Furthermore, integrating digital tools into PBL activities, such as collaborative platforms and online research resources, improves students' technological proficiency and aligns their capabilities with the digital transformation occurring in contemporary workplaces, thereby preparing them for technologically advanced work environments (Rahman, Fitria, Nurhidayah, & Yuliandani, 2022; Wyke, Aarup Jensen, Krogh, Ravn, & Svidt, 2022).

Considering this, the focus of PBL on self-directed learning and metacognitive awareness prepares students for lifelong learning, which is a vital skill in rapidly evolving professional environments. Consequently, PBL enhances academic achievement and prepares graduates for employment and future success in knowledge-based economies.

2. Research

This study examines the implementation of PBL within an English for Specific Purposes (ESP) course at the Faculty of Public Administration at the University of Ljubljana. Given that this was their first exposure to such an instructional method within their faculty's curriculum, the primary aim was to explore students' perceptions and experiences of PBL. Within the ESP framework, PBL offers students meaningful opportunities to develop language skills that directly align with their academic needs and future professional roles. Engaging with realistic scenarios enhances students' linguistic proficiency and enables them to acquire transferable skills essential for addressing challenges in public administration practice. This paper focuses on examining students' perceptions of PBL in an ESP course for administrative sciences. The following research questions were posed: (1) How do students perceive the impact of PBL on the skills they have acquired? and (2) How do students' attitudes towards PBL compare with their attitudes towards traditional teaching methods?

2.1. PBL implementation

During the 2023/24 academic year, a single PBL cycle was incorporated into a blended learning course that combined face-to-face instruction with Moodle-based activities. LLM was not used by students during this time. As the participants were unfamiliar with PBL, detailed explanations and continuous guidance were provided throughout the process, during classroom interactions and via the e-classroom where students completed tasks. Prior to the PBL phase, students acquired essential ESP skills, such as delivering oral presentations, writing summaries and communicating formally via email, in order to prepare for the new approach.

Initially, the students were organised into groups of three to six members. They were introduced to the principles of teamwork, assigned roles and signed responsibility agreements before selecting real-life problems, such as insufficient student housing or parking issues, and formulating research questions. To find solutions, the students consulted online resources and empirical research, such as questionnaires or interviews. Teamwork outside of class was facilitated via MS Teams, where shared folders enabled collaborative document creation. The teacher provided weekly feedback and guidance. The PBL cycle concluded with a formal report, a video presentation in English and a recorded meeting, all demonstrating the appropriate use of language. The implementation of PBL by week is presented in more detail in Kranjec and Keržič (2025).

2.2. Data and methodology

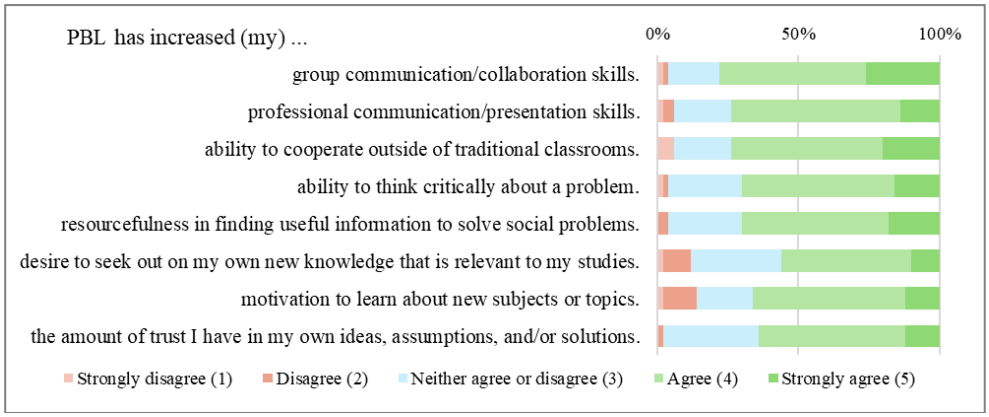
The study involved 94 first-year students enrolled in the first-cycle professional program. Based on empirical insights from the literature, a questionnaire was adapted and designed to align with the objectives of PBL implementation (Fleaher et al., 2021; Tan & Shen, 2019; Willis et al., 2002). The instrument consisted of 16 statements grouped into two categories: (1) perceived effects of PBL on various learning dimensions and (2) attitudes toward PBL compared to traditional teaching methods. Responses were measured using a five-point Likert scale ranging from 1 (strongly disagree/not at all) to 5 (strongly agree/extremely). The questionnaire was implemented in the e-classroom in the last week of the PBL project. A total of 48 students completed the questionnaire.

2.3. Results

The findings of the study provide strong evidence that PBL positively influences several key dimensions of student learning within an ESP context (see Figure1.). The majority of respondents reported improvements in collaborative and communicative skills, which is consistent with the theoretical basis of

PBL, which emphasises teamwork and active engagement (Barrows, 1996; Savery, 2006). Specifically, 78% of students agreed or strongly agreed that their group communication and collaboration skills had improved, and 74% indicated that their professional communication and presentation skills had improved. These results confirm that PBL effectively supports the development of the language competencies required in professional environments. This is consistent with previous research, which has highlighted the benefits of PBL for communication and problem-solving skills (Hmelo-Silver, 2004).

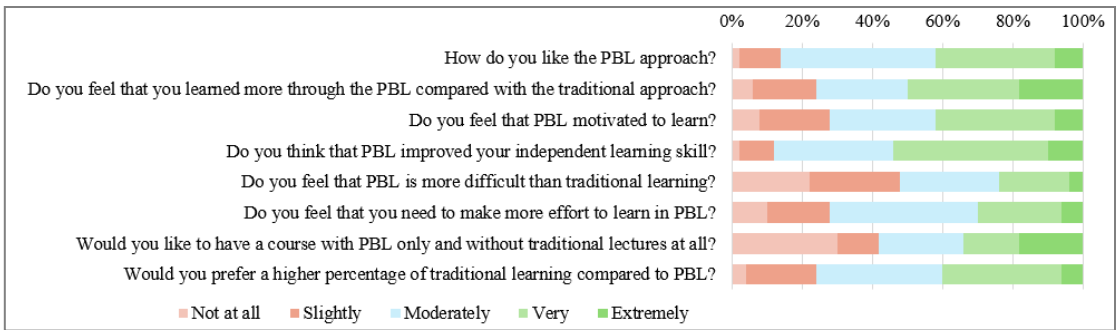
Figure 1. Students' opinions about the influence of PBL on their skills.



Similarly, PBL appears to encourage collaboration outside of the traditional classroom, with 74% of students acknowledging improvement in this area. This outcome reflects the successful integration of digital tools such as MS Teams that facilitate collaboration and document sharing. This corroborates the notion that technology-enhanced PBL environments encourage flexibility and learner autonomy (Hung, Jonassen & Liu, 2008). Critical thinking and resourcefulness also emerged as significant benefits, with 70% of students agreeing or strongly agreeing that PBL helped them think critically and find information to solve real-world problems. These findings highlight the potential of PBL to bridge the gap between theoretical knowledge and practical application, which is a key objective in higher education (Savery, 2006). However, there was more variability in the motivational and metacognitive dimensions. While 66% of students reported increased motivation to learn new topics and 56% expressed a greater desire to seek out new knowledge independently, a significant proportion of responses were neutral (20–32%). Similarly, 64% of students reported an improvement in confidence in their personal ideas and solutions, while 34% were undecided. These results suggest that although PBL promotes autonomy and self-directed learning, further support may be needed to fully develop metacognitive awareness and intrinsic motivation, as emphasised by Hmelo-Silver (2004) and Schmidt, Rotgans, and Yew (2011), for example.

The second part of the questionnaire revealed a generally positive attitude towards the PBL approach (see Figure 2). Most respondents rated their preference for PBL as 'Very' or 'Extremely', indicating strong acceptance of this method. Similarly, a high proportion of students felt that they had learnt more through PBL than through traditional approaches, suggesting that PBL is perceived as an effective method of acquiring knowledge.

Figure 2. Students' opinions about learning with PBL.



Motivation and independent learning skills were also rated highly, with most responses falling into the upper categories. This confirms PBL's role in fostering autonomy and engagement. However, perceptions of the difficulty and effort required for PBL were mixed. Many students agreed that PBL

demands more effort than traditional learning, which is consistent with its active, student-centred nature. This finding highlights the need for adequate support and guidance during the implementation of PBL.

However, when asked about a course entirely based on PBL without traditional lectures, responses were more divided, with fewer students selecting 'Very' or 'Extremely'. This suggests that, although PBL is valued, students may prefer a blended approach to a complete replacement of traditional methods. Similarly, when asked about preferring a higher percentage of traditional learning, there was moderate agreement, which reinforces the idea that a balanced combination of PBL and traditional instruction might be optimal.

Further analysis involved calculating the average values the first and second categories of students' responses, with the second category divided into those who preferred PBL versus traditional learning and those who did not. We then added the points obtained through PBL, the points collected from quizzes in the e-classroom that were unrelated to PBL, and the final grade for the course. We conducted a correlation analysis focusing on those six indicators. Both Pearson's r and Spearman's rho were calculated to capture linear and rank-based associations, given the mix of Likert-scale and performance-based measures. As expected, the strongest positive correlation was observed between the PBL points and the final grade ($r = 0.54$; $p < 0.001$), since higher PBL scores directly contribute to the overall grade. A moderate negative correlation was found between not preferred PBL versus traditional learning and the final grade ($r = -0.32$; $p < 0.03$), suggesting that students with a more negative perception of PBL tend to achieve slightly lower grades. Other variables showed only weak correlations (r between ± 0.10 and ± 0.20), indicating that subjective perceptions are not strong predictors of academic performance.

3. Discussion and conclusions

The present results show that success in PBL tasks is the main factor in determining the final grade, while attitudes towards PBL and traditional learning only indirectly influence the outcome. Although negative perceptions of PBL may coincide with lower achievement, this effect is weaker than the direct impact of task completion. Students who report greater improvement through PBL also express more positive opinions about PBL compared to traditional learning. This convergence suggests that PBL fosters not only cognitive development but also motivational and attitudinal benefits, reinforcing its pedagogical value. The correlation between the total number of PBL points and the final course grade suggests that the competencies assessed through PBL activities contribute meaningfully to the final outcome. Conversely, the weak and non-significant correlations involving average quiz scores suggest that traditional quizzes may not reflect the skills emphasised in PBL, such as problem-solving and collaboration, nor the knowledge required for the final exam. For educators, these findings emphasise the importance of assessment alignment. If course objectives prioritise PBL competencies, evaluation strategies must reflect these goals to ensure fairness and validity. Furthermore, cultivating positive attitudes towards PBL could boost engagement and perceived learning gains. The findings suggest that students with negative attitudes towards PBL may benefit from additional guidance and orientation activities to explain the advantages of active learning and help them adapt and engage more effectively. Finally, while self-reported improvements in skills are not strong predictors of achievement, encouraging metacognitive strategies through reflection and discussion can improve long-term learning outcomes and promote deeper engagement with the material.

Overall, the data indicate that PBL is highly effective in enhancing collaborative and digital competencies, while its impact on motivation and confidence requires further exploration. Future research should investigate strategies to strengthen these dimensions, such as incorporating reflective activities or peer feedback mechanisms. The integration of learning analytics indicators, such as the number of LMS logins, participation in online discussions, and task submission patterns, would provide a valuable complement to students' self-reported perceptions. Furthermore, AI-enhanced analytics introduce additional possibilities, including the predictive modelling of student engagement, early identification of learning difficulties, and adaptive feedback systems tailored to individual learners, which could timely indicate students with negative attitudes towards PBL and motivate them for active engagement. This could represent a significant step toward more personalized, responsive, and data-driven higher education. Future research should explore mixed methods approaches that combine surveys, behavioral data, and qualitative reflections, while also addressing ethical considerations in the use of learning data and the design of intelligent dashboards that support reflective learning for both students and instructors.

By integrating authentic problems, interdisciplinary collaboration, and digital tools, PBL equips graduates with the competencies essential for navigating dynamic labour markets. By centering learning on authentic, complex problems, PBL cultivates a suite of competencies, including critical thinking, collaboration, communication, adaptability, and digital literacy, that employers consistently identify as essential for success in dynamic work environments. Unlike traditional content-driven approaches, PBL

emphasizes transferable skills and reflective practice, enabling graduates to navigate uncertainty, manage interdisciplinary projects, and respond ethically to real-world challenges. Higher education must prioritize methods like PBL that foster lifelong learning and professional resilience.

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GAMIFICATION AND FACILITATION METHODS IN SUSTAINABILITY TRAINING FOR SMES

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Abstract

Issues and requirements related to sustainable development, both at the interfaces of companies and within broader value chains, challenge SME personnel in identifying and developing the necessary and sufficient factors. Some SME employees have found it challenging to identify areas of sustainable development relevant to their operating environments. In these contexts, the need to develop one's own competence is recognized. Still, after prior training several years earlier, the effectiveness of one's study techniques and the continued employability of studying while working full-time are doubted. To meet the requirements of sustainable development, both as part of value chains and to maintain competitiveness with end users, SMEs must ensure that their personnel possess sufficient sustainability competence within their operating environments. To meet these needs, studies on sustainable development were conducted that employed gamification, for example, through the facilitation of Lego Serious Play and Cambridge Value Mapping. These approaches were chosen to lower the threshold for participation in the training and to enable a more concrete understanding of the interfaces and the development of sustainable development in one's own operating environment. In addition, gamification and various facilitation methods are part of higher education. The methods are seen as motivating, participatory, intensive, and meaningful ways of studying, which make the material better understood and learning more meaningful. Flexible support, combined with gamification and facilitation, can enhance learning when examined from different perspectives. In gamification, learning progress can be monitored, and creative task types can be integrated into the task design. In this article, we discuss gamification and facilitation methods in online studies on corporate responsibility aimed at SME personnel, and in hybrid studies on sustainability, which included workshops conducted in face-to-face meetings using the Lego Serious Play and Cambridge Value Mapping methods. Participation in the set of tasks on corporate responsibility, implemented on the SEPPO game platform and in the workshops, was enthusiastic from the perspective of responsible SME operations. According to feedback, participants reported receiving value for their time and that their competence had increased through gamification tasks and study-related work methods.

Keywords: *SME, higher education, sustainability, gamification, facilitation.*

1. Introduction

Based on discussions with Finnish SME representatives who have participated in Laurea UAS sustainability studies, the simplification of the EU's sustainability reporting requirements in Omnibus I (Baumüller, 2025; Council of the EU, 2025) does not appear to have reduced the sustainability requirements already in place in companies' value chains. Based on the discussions, sustainable and responsible cooperation among partners and across value chains, among stakeholders and end users, will continue to strengthen the planetarity of future generations. The challenge in strengthening this is to maintain up-to-date information and expertise on EU-level directives and regulations in relation to national legislation. To enhance SMEs' responsibility and sustainability competence, training organisations have tailored continuing education programmes for companies. Some of the SME staff representatives may have been out of school for a long time since completing their previous studies. For this reason, the readily accessible concrete teaching and facilitation methods used in the training play a significant role in making the study meaningful, practical, and motivating. This article discusses gamification and facilitation methods that have received positive feedback from participants in the VALIOT project of Laurea and LAB University of Applied Sciences, and the VASTUUT project of Laurea University of Applied Sciences.

2. Design

The challenge in developing and promoting sustainable development and responsible business in SMEs is, among other things, maintaining and enhancing the competence required to keep pace with changes in regulations and related requirements, and to integrate them into everyday practices and business operations. The starting point for planning and designing studies targeting SME personnel was to connect theoretical components to participants' business environments. This was implemented in the studies, for example, by reflecting on each participant's current business environment and by selecting a range of easily accessible study forms to support content processing, such as gamification, Lego Serious Play (LSP), and Cambridge Mapping Value Tool (CMVT) workshops. Earlier individual use of these methods in the sustainability context by Laurea UAS personnel has motivated students and company representatives, even though they are not used systematically in education, but in business. Therefore, these methods were considered encouraging and feasible when sustainable business development and innovation were considered.

2.1. Gamification

In their articles, Stieglitz et al. (2016) and Lenssen et al. (2013) highlighted gamification as a motivating, participatory approach to studying more intensively and understanding materials, making learning more effective and meaningful. Jääskö et al. (2021) and Alsawaier (2018) argue that gamification is the use of game design elements, such as involvement, problem-solving, and experimental activities, to create added value for users. Game-based learning (GBL) is motivating and offers experiential learning in a risk-free environment. It is practical, generating knowledge through, for example, practical experiences, reflection, and feedback, emphasizing joint knowledge production and social learning through dialogue. The flexible support that is part of game-based learning can significantly impact learning as interest increases, for example, thanks to adaptive support, thereby strengthening the achievement of goals (Koskinen, 2023; Buckley & Doyle, 2016). Breuer et al. (2022) state that examining and redefining perspectives from the outside and studying the problem's impact on innovative activities are important.

3. Objectives

The goal of using gamification and facilitation methods is to maintain a meaningful, motivating approach to integrating knowledge with practical, business-related aspects of sustainable development and responsibility, thereby lowering the bar for participants whose studies were completed several years ago. In addition, at the game platform level, the participant can track their own progress and receive immediate feedback on the integration of sustainable development and responsibility factors into everyday business activities. This approach aims to enhance independent information retrieval and competence while benefiting the long-term competitiveness of the participant's background company.

4. Methods

The selection and utilisation of the methods used in the studies of responsibility and sustainable development discussed in the article were made possible by the licensed licences and certified facilitation trainers at Laurea University of Applied Sciences. Positive experiences have been gained from applying the methods in studies and business development, as well as through collaboration with RDI companies.

4.1. SEPPO-platform

On the Seppo platform, the learning environment can comprise gamified learning, artificial intelligence, and authentic learning environments, thereby putting learning into practice and supporting real change. When using an AI-based game engine, SAIGE artificial intelligence transforms materials into gamified learning experiences. In a 3D environment, SolidSafe can be used to develop customer-specific 3D environments based on real operating environments. In games built on the SEPPO platform, participants are engaged through scoring, levels, leaderboards, feedback, and branching game paths. To progress through the game, you can use task types, such as multiple choice, missing word, creative tasks, or combining pairs. The answers suitable for the task can be text, audio, video, or images, from which you can choose one or more methods. The actual gameplay can take place indoors, outdoors, remotely, or on-site using platforms such as images, location-based maps, and 360° images. The participant progresses along paths on the game platform, and tasks can be opened to participants individually, in stages based on role and progress, personalized to the learning path, or all at once. Feedback can be provided in real time, via automated feedback, or in a personalized manner after assignments have been submitted. (Liitutaulu, 2025).

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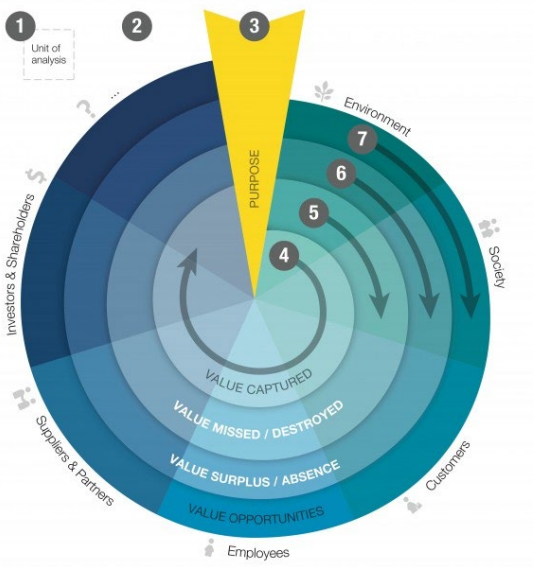
4.2. Lego serious play

LEGO® SERIOUS PLAY® (LSP) is used to engage, inspire, and enable players to come up with ideas for faster implementations. The method emphasizes a participatory process, outsourcing thinking and facilitating communication and problem-solving, for example, among an assembled team. The technology is grounded in research on psychology and learning, among other areas. The starting point is that the participants do not have all the answers, and success depends on sharing information and taking all participants into account. In addition, it is grounded in mutual appreciation and participants' willingness to take responsibility. This is how collaboration and interaction lead to sustainable business. LSP can be used to develop, for example, business and communications by combining participants' gamification with strategic ideas. The use of Legos facilitates creative thinking and imagination, as well as the expression of honest opinions (Kristiansen & Rasmussen, 2014). Colasante & Fitsilis (2020) report that they have used LSP to empower adult learners, which aligns with LSP's motivating, participatory, and engaging approach.

4.3. Cambridge value mapping tool

The Cambridge Value Mapping Tool (CVMT) is designed to structure the value creation in sustainable business operations. CVMT work considers and structures the value created for the business's stakeholders under the existing business model, as well as the threats and the concrete and intangible value exchanges in the long term. The work identifies where value is created and where it is not. The identification uses a visual approach to assess successful and unsuccessful value creation in the business network from the perspectives of different stakeholders, taking into account sustainable development, for example, in terms of the environment and society. Through the work, participants gain a deeper understanding of their business's value creation and identify new economic, social, and environmental benefits. The areas are examined and considered using the visual outline below, which focuses on, for example, the business product, stakeholders, purpose, current value, hidden or past values, value surplus or deficit, and new value opportunities (University of Cambridge, 2026).

Figure 1. Visual Cambridge Value Mapping Tool, (University of Cambridge, 2026).



5. Discussion

The starting point for selecting gamification and facilitation methods for the project studies was the sustainable development of SMEs. Using the different task formats and game levels of the SEPPO game platform, the participants (90) examined the company's starting level of sustainable development. They considered the current state of the business's economic, social, and environmental responsibilities and related them to the company's goals. After the examinations took place, sustainable development and responsibility became concrete and took shape for the participants through everyday business activities, for example, in relation to daily routines and planning, thereby strengthening their competence. There were five levels of play, the first of which examined the prevailing attitude and existing sustainability practices in the company. The following three levels included economic, social, and environmental responsibility, in connection with which the participants listened to podcasts and read articles, and based on which they

considered similar issues from their own operating environment. On the last fifth level, the participants reflect on the topics discussed in the company's future operating environment.

The Cambridge Value Mapping Tool (CVMT) has been developed specifically for value creation in responsible and sustainable business. The participants of the CVMT workshop (10 participants) first used an example case to consider value-creation perspectives, including existing value, lost value, and new opportunities for value creation. After discussing the example, the participants focused on creating value for business stakeholders in their respective fields or companies, using the circles of a visual framework to step-by-step examine perspectives on responsible, sustainable value creation over the long term. The participants felt that the gradual approach to value creation facilitated addressing a challenging topic and gained new ideas about the possibilities of sustainable and responsible value creation in business.

In the Lego Serious Play workshops (36 participants), participants were divided into small groups and, after an initial introduction to Legos, built with them using warm-up tasks within the allotted time. Subsequently, LEGO building was combined with storytelling, enabling all participants to create their own structure and story based on the exact instructions. After building exercises with Legos, the participants developed concepts suitable for responsible everyday use, drawing on the economic, social, and environmental dimensions of responsibility. The responsible and sustainable concepts developed with LEGO were presented clearly and concisely to the other participants. The participants discussed the creation of flight of ideas by outsourcing concept ideas to Legos and by engaging strongly with Legos in connection with their work with Legos.

6. Conclusions

In discussions held in connection with their studies, participants in the SEPPO game platform, the Cambridge Value Mapping Tool, and Lego Serious Play workshops reported that they apply the ideas, values, and innovations they have learned and brainstormed in the game and workshops to their business and everyday activities in their operating environment. The participants felt they had combined theory on responsibility and sustainable development with practical business values and innovations, and that they had strengthened their practical competence in these areas. In the final discussions, the participants stated that they had either already shared, or would share with their colleagues, what they had learned or developed in the game and the workshops on developing responsible and sustainable business.

Based on participants' shared experiences, the facilitation methods employed individually, and the game platform supported the integration of theoretical knowledge and practical measures, thereby deepening understanding. Combining these three operating methods and the continuum they create constitutes an alternative, based on feedback from discussions conducted as part of a broader study module.

One limitation was the use of methods as separate entities within individual study modules, with no option to combine them into a single, comprehensive framework. As a result, the participants lacked a clear, broad understanding of the entity and continuum of connections between sustainable development and the understanding of sustainability-related information and practical business at all levels, which were examined and developed using the methods.

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OPPORTUNITIES AND CHALLENGES OF AI IN EDUCATION: A DIDACTIC PERSPECTIVE

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Abstract

The complexity inherent in lesson planning represents a significant challenge, particularly for novice teachers or those in training. A wide range of conditions must be taken into account, and highly interrelated decisions must be made. Furthermore, the individualization of learning processes for learners in learning groups of 25 or more participants represents a problem not only for novice teachers. For this reason, the present paper examines the question of how action-oriented teaching for vocational schools can be planned and evaluated with the help of generative AI tools. The technical focus is on the teaching of the fundamentals of electrical engineering, with a particular emphasis on addressing and, if necessary, correcting learners' preconceptions.

Keywords: *Constructivist didactics of electrical engineering (cDoEE), fundamentals of electrical engineering, preconceptions, learning plan.*

1. Introduction

Machine learning and artificial intelligence have permeated all facets of human life and are now an integral part of daily life in educational institutions at all levels. In the domain of education, a number of advantages emerge for learners and teachers, thereby facilitating more efficient learning and teaching processes. With a focus on pedagogical practices, artificial intelligence (AI) can facilitate the individualized planning of lessons and the creation of learning materials for each learner. Furthermore, they can provide assistance to educators in the process of evaluating homework assignments and grading examination results. With regard to this aspect, however, the responsibility for the possible assessment of learners must remain with human teachers, even if there is certainly a temptation to shift this responsibility and the associated apparent objectivity of assessment. The present paper aims to answer the following research question:

How might teaching in the field of electrical engineering fundamentals be arranged with the assistance of AI tools from a subject didactics' perspective?

In order to respond to this question, an initial presentation of theoretical background information will be made, with a focus on the author's teaching background and a selection of AI tools. The subsequent sections will elaborate on the three domains identified above in which AI tools can be utilized. It is not feasible to furnish a comprehensive response to the aforementioned query due to the intricacy and breadth of the subject matter. Instead, the objective of this paper is to contribute to the ongoing discourse on the appropriate and ethically acceptable utilization of AI tools.

2. Theoretical framework

The theoretical framework of this article is rooted in Constructivist Didactics of Electrical Engineering (cDoEE) (Jambor, 2022), a methodological approach that emphasizes the instruction of fundamentals of electrical engineering within the context of vocational schools. Consequently, the subject didactics is presented first. In the following section, an explanation will be provided regarding the selection of AI tools utilized in this article.

2.1. Constructivist didactics of electrical engineering (cDoEE)

The cDoEE is based on constructivist learning theory (Chuang, 2021). Consequently, the activation of learners constitutes a pivotal component within the framework of learning-teaching arrangements. This approach enables learners to construct their structures (knowledge and skills) in a self-regulated manner. The concept of action orientation, a mandatory component of German vocational education, fosters this self-regulated learning. Within the framework of cDoEE, this concept is described on the basis of six abstract characteristics, which include, for example, subject reference, practical relevance, and metacommunication. Due to the inherent abstract nature of the characteristics, it is not possible to design concrete learning-teaching arrangements directly. Consequently, ten determinants are derived from these characteristics, thereby enabling such design. Examples of such determinants include internal differentiation, action structure, and action product. The description of the individual characteristics and determining factors can be found in Jambor (2024) and Jambor (2025a).

Since the three aforementioned determinants are relevant to this article, they will be outlined briefly here. Internal differentiation addresses the understanding that learners can only construct internal structures if information is meaningful and can be linked to existing cognitive structures (connectivity). Therefore, it is important to analyze learners and adapt teaching activities to their individual needs and motivational situations. One way to increase motivation is to use practical action products (e.g., repairing a DVD player) as the focus of learning activities. Additionally, structuring the learning process by the action structure supports learners and makes it easier for them to deal with complex action products. This process is based on the six phases of complete action: informing, planning, deciding, executing, checking, and evaluating (Lindemann, 2002). The author of this article adds an additional phase. This phase is the problem definition phase, in which learners analyze the problem and establish a motivational foundation for subsequent phases.

The aforementioned connectivity of new information may be influenced by preconceptions. These are explanatory patterns generated by learners through previous learning processes. Sometimes, these preconceptions are based on special cases and generalized without sufficient reflection. In this case, they are no longer valid and lead to a false understanding of context. These preconceptions are then classified as unhelpful (Jambor, 2025b) or misconceptions (Daud et al., 2015). One example of such a preconception is a series connection consisting of a resistor, an LED, and another resistor. While most learners think the first resistor limits the current through the LED, a few believe the second resistor has no influence. This is because the second resistor is located behind the LED. This idea is, of course, incorrect and makes constructing new knowledge difficult.

2.2. Selection of AI tools

Teachers reach their limits when they have to supervise 25 or more learners in a teaching-learning arrangement, particularly with regard to the determinant of internal differentiation. Even in an action-oriented, student-active setting, it is only possible to a limited extent to respond to learners' individual needs. This also relates to preconceptions. Teachers must recognize learners' unhelpful preconceptions and support them in reducing these preconceptions through explicit tasks. These processes are highly individual. Using generative AI tools can increase the individualization of materials and media, so that the needs of learners are better met.

In this paper, two generative AI tools will be used: ChatGPT 5.2 and Gemini 3 Flash. These tools will be referenced without their version names below. ChatGPT is used for this study because it is widely popular among learners and teachers. Gemini has already proven effective for subject-specific teaching purposes in previous studies, so it is also used here.

3. Use of generative AI tools

Both AI tools are provided with a brief description of fictional first-year “electronics technicians for devices and systems” (“Elektroniker für Geräte und Systeme”) students. Learning Field 1, "Analyzing Electrical Engineering Systems and Testing Functions," is specified as the curriculum requirement because it focuses on the fundamentals of electrical engineering. Additionally, the individual competencies and content that should be the focus of the learning situation are specified for the AI tools. It is also specified that the entire learning situation should include 14 teaching hours and focus primarily on preconceptions. Since the author's research focuses on future teachers, this is included in the prompt for the AI tool.

3.1. Lesson plans

Since this article focuses on designing concepts for teaching rather than formal lesson plans, the formal criteria in (Jambor, 2025c) are not used here. Instead, the focus is on the subject-specific didactic aspects of the learning situations designed by AI tools. However, before these plans are created, the AI tools should suggest action products that are central to the learning situation.

The range of suggested action products by ChatGPT spans from a poster titled “This is how I imagine electricity,” to a comparison of series and parallel connections, as well as measurement instructions titled “Measuring correctly with a multimeter,” and a measurement report. In the author's view, the analysis of a simple lighting circuit and troubleshooting in a circuit diagram have the greatest motivational potential and relevance to the profession. Gemini makes similar suggestions; however, a concept map is a notable option because it allows learners to visualize their thoughts. A guide to troubleshooting and a real light control circuit are cited as action products with the greatest practical relevance. Overall, most of the suggestions can be effectively implemented in an action-oriented, learning-teaching arrangement.

For rough planning of the learning situation, the author selects a suggestion for the action product in both cases, using the real circuit. Although neither AI tool is directly oriented toward the complete action, a meaningful action structure can be identified. However, upon request, both AI tools can assign the action to the phases of the complete action. Gemini optimizes its own design and integrates project-based approaches. While ChatGPT focuses on individual lessons, Gemini plans double lessons; however, ChatGPT also combines individual lessons into blocks. ChatGPT switches between individual work, group work, and frontal teaching in terms of social form. While the variety of social forms in ChatGPT is useful, it introduces a certain amount of disruption when working on the task. Learners may lose focus on the collaborative creation of the action product if they change social forms too often. Currently, Gemini does not provide specific information about the social form within lessons, though this is not an issue at the planning stage. However, at the end of the rough planning process, Gemini offers the suggestion that students be divided into groups of nine or thirteen, which are then divided into groups of two or three. These groups should be heterogeneous in terms of performance and learning requirements. Since the author misunderstands the team approach, Gemini clarifies that the groups have no didactic significance.

According to the rough planning, both AI tools must plan a lesson in greater detail. The author selected a lesson from both drafts that offer opportunities to deal with preconceptions. ChatGPT employs a combination of frontal teaching and group work at this stage. The task, which consists of two circuits, is presented on the board and subsequently addressed in groups using worksheets. The results of these exercises are subsequently documented on the board. It is noteworthy that ChatGPT has indicated that experiments will be conducted in the subsequent lesson. According to the Gemini approach, which is designed to facilitate double lessons, the educational session is initiated with a deliberate provocation. From the author's perspective, this approach is intended to stimulate the students' interest and motivate them to work on the problem. Subsequently, the students engage in a series of experiments, the outcomes of which are subsequently summarized in a frontal setting. Based on their observations, the students perform calculations (group work, frontal teaching), so that knowledge transfer is ensured. The two lesson plans demonstrate an evident commitment to addressing preconceptions through both theoretical and practical approaches. This is a particularly useful approach within the framework of constructivist learning theory. In this particular instance, the author posits that Gemini's methodology is more efficacious, as it confronts learners with authentic, real-world problems that address their existing preconceptions. This methodological approach creates cognitive conflicts, compelling learners to introspect and engage in self-reflection, particularly regarding their existing preconceptions. Nevertheless, this analysis does not imply that ChatGPT's approach is ineffective. The formulation of assumptions and subsequent confirmation or falsification of these assumptions through theoretical exercises can also be regarded as a valuable activity. This is particularly true in the context of subsequent practical exercise. With regard to the target group (vocational school students), this approach is less suitable.

In addition to the process of lesson planning, both AI tools are tasked with the identification of potential comprehension issues and the development of courses of action for the teacher. ChatGPT's primary focus is on preconceptions and the issue of associating circuit diagrams with real circuits. The range of suggested options includes a positive error culture (allowing errors and viewing them as learning opportunities), practical experiments, and teacher-student dialogues (e.g., "Where do you measure the voltage?" "Why?"). Another option is to follow the current paths with a finger and reflect on the results. Gemini also systematizes suggestions based on possible preconceptions. The proposed methodologies encompass the utilization of a water flow model, an analogy to a supermarket checkout, and a role-playing scenario in which students adopt the roles of "pump," "electrons," "resistance," and "measuring master." It can be posited that Gemini's suggestions exhibit a degree of “creativity”. Moreover, the approaches proposed by ChatGPT and Gemini can be regarded as didactically useful and implementable in a vocational

school setting. In particular, the implementation of role-playing as a pedagogical method requires adaptation to the target group and a systematic introduction. Finally, it is imperative to underscore the potential risks associated with the utilization of analogies, as many preconceptions are rooted in the water flow model or similar analogies.

3.2. Teaching materials

As delineated in Section 3.1, the lesson planning process includes a request for AI tools to generate several teaching materials. The primary focus at this stage is on the planning of lessons, which were developed in detail. ChatGPT generates a board draft (possible result of class activities) and a worksheet. The board draft offers a useful comparison of series and parallel connections. In addition to addressing the configuration of the circuits and the behavior of current and voltage, the draft includes a discussion of the consequences of lamp failure and the relative brightness of the lamps. The final point may be slightly misleading. According to ChatGPT, the lamps should be dimmer in a series connection and equally bright in a parallel connection. This may foster the preconception that lamps in a series connection become darker as they are positioned further away from the positive pole. At this point, the intervention of a teacher is necessary. The ChatGPT worksheet comprises a combination of open-ended and multiple-choice questions. For the multiple-choice questions, learners are required to provide written justifications for their selected response. In the worksheet, learners engage with the content that has been summarized on the board. Furthermore, the worksheet contains a task that requires learners to apply their knowledge, thereby facilitating the transition from learning objectives at a low taxonomy level to learning objectives at a higher taxonomy level (Bloom et al., 1964).

Initially, Gemini offers a comparable board draft, but it does not exhibit the problematic representation of brightness. Furthermore, the electrical engineering relationships are presented in the form of mathematical formulas. The necessity of the mathematical description of the relationships becomes evident in the Gemini worksheet, as calculations for series and parallel connections are performed here. Two resistors (R1=200 ohms, R2=300 ohms) are used as examples in this analysis. It is imperative to underscore that the "commercially available" values from the E24 series are particularly relevant in the context of vocational education. In addition to the calculations, a "pre-concept check" question is included, which requires a more profound understanding of the subject matter among the learners. This is a reasonable and comprehensible perspective, although it should be noted that only a single such question is present in this instance. Furthermore, an expert bonus question is included, providing a mixed circuit for lower-performing learners and a simulation task for higher-performing learners. This is not the only example in the entire draft where Gemini provides internal differentiation without being requested to do so. Such tasks and hints can serve as a valuable support mechanism, particularly for novice teachers.

As previously delineated in Section 3.1, the two AI tools are tasked with estimating potential issues in teaching. In this context, they are instructed to create an additional worksheet to assist in dealing with two problems selected by the author. ChatGPT generates two worksheets that employ mnemonics to address preconceptions (e.g., “There are no branches in a series connection. The current is therefore constant in all points"). Furthermore, learners are requested to perform measurements and visualize current paths. The results of these measurements are reflected using the worksheet. According to the recommendation provided by ChatGPT, the worksheet can be made available to learners before, during, or after the experiment. From a didactic perspective, these measures can be regarded as useful and effective. Gemini employs analogies once more in this context, aligning with the recommendation made by ChatGPT that measurements be taken. Notwithstanding the problem of analogies potentially reinforcing preconceptions, this approach is beneficial for learners in their first year of training. As the analogies are supplemented by empirical measurements on real circuits, this risk is reduced.

3.3. Assessment of student results

In the context of evaluating student performance, automated assessment of single-choice and multiple-choice tasks is particularly straightforward. A notable disadvantage of this approach is that it exclusively evaluates learning objectives at low taxonomy levels. The evaluation of calculation results, wherein the sole focus is on the result itself, does not impose significant demands on the tools. However, given the absence of direct information regarding the learners' skills, a more thorough examination of the calculation process is necessary. This assertion extends to the evaluation of open-ended inquiries and the learners' approach, thereby rendering the utilization of AI tools indispensable for the automation of assessments, whether in their entirety or in part.

Savytska et al., for instance, demonstrate the feasibility of automated physical calculation evaluation through the integration of AI tools (Savytska et al., 2025). In addition, Chan and Lee have observed that reflective texts that emphasize one's own approach and thus a more profound process-oriented understanding are also favorably evaluated by AI tools. In this case, artificial intelligence has been shown

to demonstrate a higher degree of consistency in its evaluation process when compared to that of human evaluators. Additionally, it has been observed that AI exhibits a certain bias that favors linguistic clarity and the structuring of reflection (Chan and Lee, 2025). This bias is not always imperceptible in human evaluators. Consequently, the utilization of AI can be regarded as technically appropriate. The fundamental issue is rooted in the legal and ethical domains. Presently, the author is unaware of any legal framework that would permit the exclusive evaluation of student performance in Germany using exclusively AI. Nevertheless, it is feasible to provide teachers with assistance in their assessment. Moreover, data protection regulations must be considered, as highly sensitive learner data is made accessible to the AI system. In addition to the legal aspects, when deciding for or against the use of AI, it is important to consider the extent to which responsibility for assessment remains with human teachers and is not shifted to the machine support unit.

4. Conclusion and outlook

In addressing the research question, it can be concluded that the use of AI tools in the domain of teaching planning is a viable and effective approach. The examined examples demonstrated adherence to the concept of action orientation, consideration of preconceptions, methodological diversity, and adequate assessment of potential problems in teaching implementation. Gemini demonstrates subject-specific "creativity" in the methodological design and use of analogies to explain electrical engineering fundamentals. A similar positive assessment can be given to the teaching materials that were created. These resources are well structured and facilitate explicit engagement with preconceptions. Concurrently, it is imperative to acknowledge the necessity of critically evaluating the outputs of AI tools. This is because not all methodological decisions are meaningful in their entirety and, above all, appropriate for the target group. Moreover, the implementation of these proposed strategies has the capacity to engender novel preconceptions or to reinforce existing ones, thereby necessitating corrective intervention by the teacher. A similar degree of skepticism must be applied when evaluating student results, as it is not the technical aspects but the didactic, ethical, and legal ones of the evaluation that must always be questioned.

Future work will concentrate on the use of supplementary AI tools, the stability of the generated results in terms of quality, the consideration of specific preconceptions, and their systematization.

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"2 LONG 2 READ": STUDENT PERCEPTION OF READING IN HIGHER EDUCATION INSTITUTIONS

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Abstract

With the rise of digital technology, Higher Education Institutions (HEIs) were initially reticent to replace traditional teaching modes with digital tools. Nonetheless, they adapted to the reality of our increasingly digitalized society where the learning environment is characterized by a complete infusion of technology in the life and learning of our today's students. They live in a digital age with high rapidity and ongoing stimulation, which often translates into multitasking and a desire to 'speed-date' through information, hopping from one source to another and rapidly choosing the one that interests them most. Paper-based tools are replaced by digital devices. Thus, learning takes place in a space of rapid resources and quick fixes, reducing the time spent on traditionally 'tedious' academic tasks like reading full textbooks or writing 5,000-word essays. What are the consequences of this major change? The effort and pride in truly assimilating what has been read, the 'a-ha' moments of yore, seem to be outdated. Research has proven that authentic learning needs time. Digital tools tout their time-saving features. Ideally, these two concepts would join together, i.e., using technology to save time on superficial tasks, thus leaving more time for engrossed and concentrated reading. To investigate this topic, we posit three questions: RQ1: How much time do our students spend on reading?; RQ2: Which "tool" do they use for their reading?; RQ3: What motivations do they need to read?. To gather data, surveys were sent to 500 students in one HEI in Switzerland. In accordance with the literature, today's students are less motivated to read academic texts, spend less time reading, and, when they finally read, do so in a fragmented and answer-driven manner, skimming for the answer to the prompt over reading a text in its entirety, helped by the emergence of a new tool: The introduction of Generative Artificial Intelligence (Gen AI) that supplies easy summaries of any complex text. The emphasis on saving time seems to supersede that of deep learning and authentic engagement. As our project continues, we will expand the sample to include other HEIs in Switzerland to define an inclusive learning framework that includes foundational skills for the future. The utility of technology must be questioned as young graduates need digital tools to complete certain tasks, but not at the expense of learning. Students must be prepared for a workplace that includes the *best* use of traditional and digital tools.

Keywords: *Higher Education Institutions (HEIs), students, reading, technology, literacy*.

1. Introduction

Previous research has defined learning as a process that "comprises knowledge, skills and attitudes" (Schneckenberg, Ehlers, & Adelsberger, 2010, p. 749) or "knowledge, skills and experience" (Bachmann, 2018, p. 21), or being "an integrated set of capabilities" – based on knowledge, skills, and attitudes (Grammens et al., 2022, p. 3), necessary for the process of learning. However, as a basic skill, learners need literacy or the ability to read and write (UNESCO, 2025). Yet, this first description of reading and writing can be complemented by more complex concepts to incorporate "not only a discrete set of skills but a situated, social, and ideological practice that is embedded in networks of power, agency, and technological mediation (…) interwoven within social life, history, and cultural practices" (Rapanta et al., 2025, p. 7). As educators in the 21st century in Higher Education Institution (HEI) we teach in classrooms that are filled with technology and tools, and our concern is the loss of one of the foundational bases of literacy: reading. Between supposed short-cuts and time-savings in using tools such as generative Artificial Intelligence, we question where reading fits in. After all, reading is the very basis of learning. While Vendler (2024) stated "without reading, there can be no learning", we insist that simply speaking reading *is* learning.

We acquiesce that our students are privy to technology and do not dispute its utility neither in today's classrooms nor in their daily life. To do so would be to refute any tool that could be harnessed to improve the teaching and learning environment. We accept that mobile technology is infused into today's student's lifestyle (Cain et al., 2022) – a logical consequence of the proliferation of technology being introduced into the educational realm. This follows previous technology such as calculator, word processor, home computer, or the Internet we have seen in the preceding decades. With each innovation, HEIs were concerned that it was the end of education as we know it. In fact, HEIs found that they could use the technology to increase student motivation to learn. Nonetheless, we sought to understand the price of implementing technology to replace the **base** of learning, that of reading. Their extensive use of technology is considered to have conditioned today's students (Choudhary & Pandita, 2023) into impatient consumers who prefer engaging in microlearning for its instant gratification and frequent rewards (Prensky, 2001) than making the efforts to attain deep, authentic learning.

To investigate this topic, we posit three questions:

RQ1: How often do our students spend time reading?

RQ2: Which "tool" do they use for their reading?

RQ3: What motivations do they need to read?

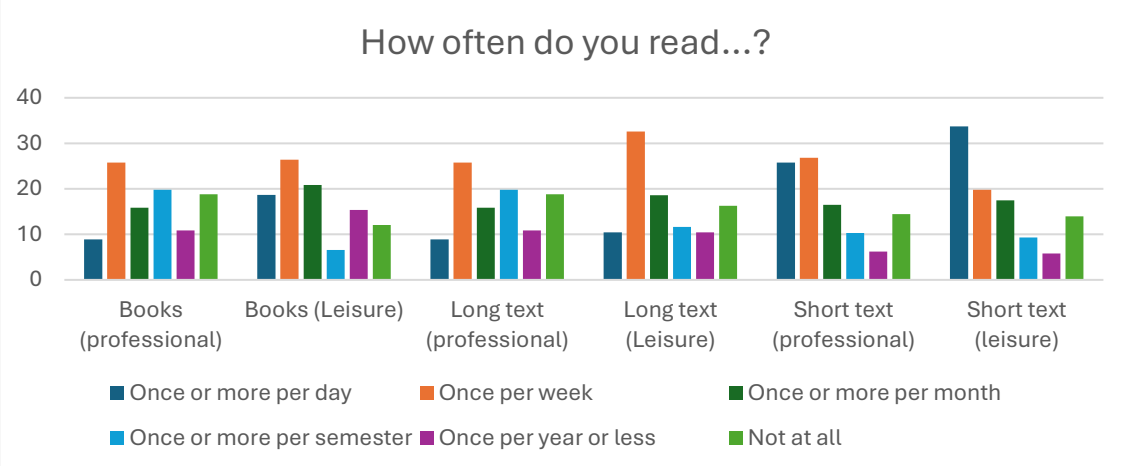
2. Methodology

To gather data, surveys were sent to 500 students in one HEI in Switzerland where they study to obtain their bachelor's in business administration, resulting in 126 usable results. For demographics, 51.5% were male and the students derived from all semesters combined. The survey was sent the 20th of October 2025 using Lime Survey, a tool that guarantees anonymity and is thus a secure tool for scientific research. The use of the data for scientific use was declared according to scientific standards. The questionnaire included 4 questions about the persons (age, sex, profession); 16 closed questions with 8 offering the possibility to make comments and 5 open questions.

3. Results

3.1. Time spent reading

Figure 1. Frequency of Reading.



As seen in Figure 1, short texts, particularly for leisure, are read once or more a day. The question did not specify for learning purposes only, thus, this result could include text messages, SMS, or social media prompts. Books (for professional learning purposes) are read on a weekly or monthly basis, yet almost 20% do not read books at all. In fact, in each of the reading categories, over 10% do not read anything. Where, or more importantly, *how* do they get their information? Further, if they are doing group projects, does the work fall in their classmates? This is a disconcerting statistic which suggests loafers in the classrooms. This aligns with previous research from the Allensbach-Institute which found that in 2024, only 17% of the students read daily, in 2002 the number was 43%. Further, one-fifth do not even look at a book once a month (Agarwala & Spiewak, 2025). Thus, reading habits are diminishing – together with the reading skills, as reading is a competence that needs to be practiced regularly: "A skilled reader needs to

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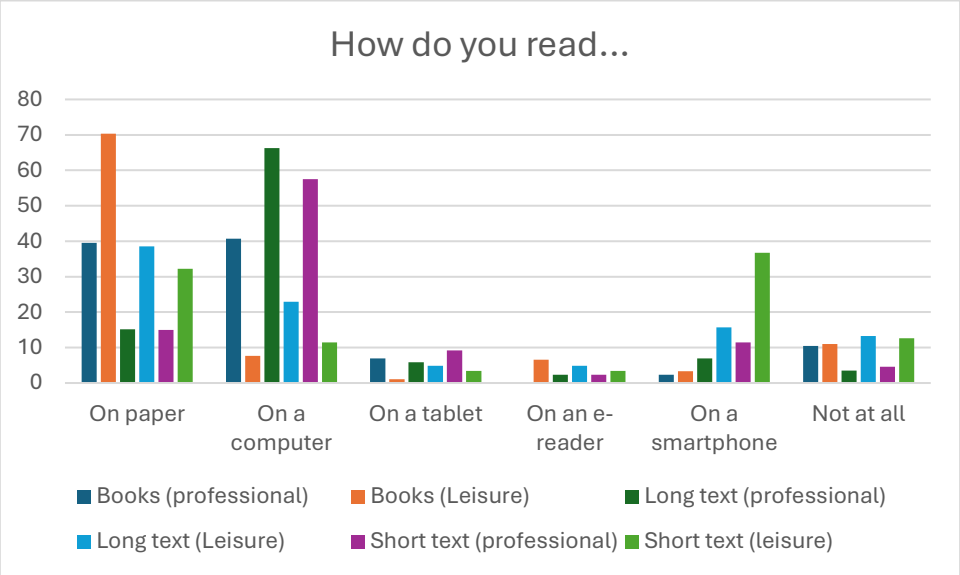
read." (S. Sawchuk, 2024). Learners who fail in this competence, may fail further, as according to Andrianatos (2019), "many learners who pass through the education system exit without being able to comprehend what they read" (p. 1), leading later to academic failure.

3.2. Reading medium

Figure 2. Reading Medium.



Overall, paper and computer score high for our respondents. We were surprised by the result for the book for leisure: it scored highest on paper (70%) but lowest of all for 'on a tablet' (2%). As the tablet has a larger screen than a smartphone, it seemed logical that it would be preferred, yet it was not. For both short and long professional texts, the computer is the preferred medium. However, smartphones recorded the highest score for short texts for leisure. From these results, we reckon that paper and computer will remain steadfast choices moving forward. Nonetheless, this choice has consequences, as reading digitally or on paper are characterized by different forms of processing (FAZ, 2019). According to this study, reading on paper is better for comprehension and memorizing and especially reading long texts is necessary "for a range of cognitive skills such as concentration, vocabulary building, and memory" (Ibid.) Comprehension and concentration are indeed hampered when reading on screens, as this type of reading is typically done by browsing or scanning the text, by looking out for keywords without turning back to passages already read – thus it's a very selective form of reading (Liu, 2005). Reading texts on the internet can be characterized as a constant distractedness (Carr, 2020) via pop-up messages or hyperlinks that push us to make choices whether to use the link or not and thus interrupting the process of reading which "impede(s) comprehension and retention" (Carr, 2020, p. 122). The mental stimulation is much more important when reading on screen, compared to the private lecture for leisure done on a paper script, that allows us to immerge ourselves into the story. This sort of "under-stimulation" compared to the reading on the net helps to filter out distractions and so "deep reading becomes a form of deep thinking" (Carr, 2020, p. 123).

3.3. Motivation/demotivation for reading

When we asked our students what motivates them and what demotivates them to read, we collected 58 answers to this non-obligatory question for the motivational aspects and 62 answers for demotivation. We translated these answers into categories and created the following word-clouds:

Figure 3. What motivates (left) and demotivates (right) students from reading?

From Figure 3, we confirm that reading is still present (and appreciated) in today's HEI students. They are motivated to read for recreation, to learn new things, and expand their knowledge. Nonetheless, the lack of time and effort that it entails, together with boredom are cited as demotivating factors. The format seems to be problematic as it suggests that students would be willing to read if they were offered a choice in the reading medium. For most of them, time is needed. Reading long, professional text seems difficult for students, since this activity takes much time and they often lack the vocabulary for an easy understanding. According to Andrianatos (2019, p. 5), students "run a 'cost-benefit analysis' before they start to read a long and complicated text and will accomplish the task only if there's a clear link between text, task and learning objectives".

With the rising speed of the net, its system of rapid responses and rewards, its stimuli and distractions, it is becoming harder to build endurance and stamina, and resilience. Sawchuk (2024) stated that reading is an exercise in attention, and, as attention is increasingly fragmented, stamina-building is needed. Moving forward, HEIs will need to consider what they are asking students to read, when, how and why and to clearly explain these demands to the students, as reading long, professional texts on paper is an activity apparently outside their comfort zone.

4. Conclusions

As seen in our study, HEI students are not completely averse to reading which suggests that there is still time to react. We need to find engaging and innovative reading opportunities that immerse students in other worlds and help them to disconnect from the world and, subsequently, the technology that goes with it. Thus, with the potential for reading opportunities at our fingertips, our overarching question changes to "Who adapts to whom?" Typically, students have been expected to adapt to the HEIs carefully planned and implemented teaching and learning environment (Rue, 2018), but what if we were at the cusp of change? What if HEIs analyzed the changed learning environment in our digital world to adapt to the needs of our 21st century students (Hayles, 2007)? They might not read entire libraries of books but perhaps feel happy to delve into a new world of scientific texts where they can find food for thought.

While many experts are (again) questioning the necessity of traditional HEI education now that Gen AI is here to stay, we are calling for improvements of the **basic skills**, i.e., analytical and critical thinking, as well as reflection to be (re)introduced into today's classrooms.

We offer three recommendations to encourage reading in HEIs today:

1. Make reading meaningful with perhaps fewer, but deeper texts.
2. Offer mediums that students are not necessarily comfortable with.
3. Co-create reading lists with the students. Inspire them to share their best reads with others.

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TRANSFORMATIVE TEACHING AND LEARNING: HOW TO BRIDGE SPANISH LANGUAGE LEARNING AND LIVED EXPERIENCES IN A LATIN AMERICAN LITERATURE CLASSROOM?

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Abstract

This study examines students' perspectives on Latin-American identity literary representations. Experiential Pedagogies emphasize the importance of bridging students' voices through dialogue. This empirical project explored how dialogue encouraged reflection, and collaboration as community-based practice. The dialogic activity facilitated a space for students' linguistic proficiency, intercultural competence, and personal growth. The anonymous students' data from 16 self-reflections in the circle of voices was analyzed qualitatively based on experiential practices through descriptive interpretative analysis. The findings indicate that students perceived discussions as space to express their feelings on identity. Also, the students' essays' analysis focuses on guided questions to identify skills and themes illustrating their progress in spoken language. These findings contribute to deeper understanding of students' perceptions on identity and practice of Spanish as a foreign language in higher education.

Keywords: *Linguistic and cultural competence, dialogue, Ikeda/Soka studies, experiential learning, identity.*

1. Introduction

In higher education, experiential learning practices extend to the Spanish learning classrooms. Experiential learning is a process through which students develop knowledge, skills, and values from direct experiences outside a traditional academic setting. As society evolves toward global citizenship, the design of experiential learning activities focuses on students' agency and cultural awareness to engage with other cultures and in dialogue with people's stories.

This approach encompasses various activities, including research and creative experiences. In teaching and learning the Spanish language, Latin America literature has been a tool to connect with the narratives on identity. Cultural background contextualizes situations for students to practice reading, writing, speaking and listening at the Intermediate Spanish language. Students incorporate Latin American narratives into their own world with the purpose to make connections with their personal stories.

Within Ikeda/ Soka Studies education, experiential learning enhances students' happiness, knowledge, and a sense of contributing to the world by connecting theory to tangible experiences. When discussing transformative education approaches, value creating pedagogy is "a knowledge system comprising methods for cultivating individuals capable of creating value" (Goulah, 2021). The goal of education, as aim of the value creating education, is "to enhance this value of human character" (Goulah, 2021). When people are empowered to realize the full scope of their possibilities, willingly unite in solidarity to confront global issues.

Dialogue as a means of interconnectedness and coexistence to restore humanity (Urbain, 2010; Goulah & Ito, 2012; Bradford, 2018, 2021; Sharma, 2018; Rita, 2021; Goulah, 2009, 2010). The Japanese educator, philosopher, poet, and peace maker Daisaku Ikeda (1928-2023) attributes dialogue as the way to connect with other cultures "by immersion in the ocean of language and dialogue" (Ikeda, 2008). Ikeda advocates and demonstrates a broader vision of value creating education through dialogue, global citizenship in the context of "human education" and the mentor relationship (Goulah, 2012). Overall, education fostering dialogue and conversations, "is far more than the mere transfer of information and knowledge; it enables to rise above the confines of our parochial perspectives and passions" (Ikeda, 2008).

Experiential learning emphasizes the importance of cultivating connections with the community. In particular, the Kolb (1984) experiential learning theory proposes four stages: concrete experience, reflective observation, abstract conceptualization, and active experimentation. Students' perceptions on

their surrounding are engaged with the readings stories to reflect on the identity experiences read in unfamiliar Latin American narratives with the purpose to apply what they learned after self-reflect on different situations. Kolb (1984) states. “Learning is the process whereby knowledge is created through the transformation of experience.”

Experiential learning practices have been researched in the context of foreign language education based on providing authentic and immerse language experiences by doing active engagement, and real-world application (Toledo, 2024). Community experiences among Spanish learners are related to the use of the language. In most cases, students mention the lack of vocabulary as a communication problem. However, the importance of connecting among peers is reflected in community engagement and politics related to different identities. To bridge the gap, the focus on dialogue as a circle of voices aims to create connections among different individual experiences with other classmates to later connect similitudes and differences identified on representations in Latin American literary works and in real life communities in the United States.

2. Design

In teaching and learning languages in higher education, literature courses frame the practice of spoken and written Spanish language discussions. According to the American Council of Teaching Foreign Languages (ACTFL), Intermediate students achieve language proficiency by immersing themselves in interpretative, interpersonal, and presentational modes of communication. Discussions take the form of simulating a circle of voices. Within this technique, they could practice with classmates.

Mapping on experiential learning Kolb theory (1984), the designing of the discussion project Circle of Voices facilitated students’ interactions. The circle of voices is a technique used by First Nations people to discuss issues of importance to everyone. Brookfield & Preskill (2005) in *Discussion as a Way of Teaching* note that for some students, the circle can be liberating, for others, it can be an ambiguous or humiliating experience. The circle of voices can help mitigate power dynamics in the classroom by providing equity in time and Student to speak.

In an asynchronous classroom environment, the variation is to video themselves reflecting posed guided questions from which they choose the one that relates to firsthand experiences. Students reply to different students weekly, trying to simulate a circular conversation. After listening to the video, they talked. Expressing thoughts is an opportunity to express how they feel about different topics. The video time is 3 to 5 minutes, allowing students time to express ideas without reading. The listener replies start with outlining ideas that connect or contrast with personal situations. Then, the listener adds related information to engage in meaningful dialogue, as a soft skill. The frequency of the circle of voices happened six times during the 15 weeks semester.

The course included 14 literary Latin American works (poetry, short stories, drama, and film) during fifteen semester weeks. The focus was to practice close reading, analytical, and critical thinking, and open questions focused on individual experiences related to literary works themes. The main themes on different identities (ethnicity, race, class, gender, existentialist (-ism), temporal, spatial, political, and sexual) guided the spoken discussions. Lived experiences were the starting point before starting the readings.

The assigned readings were 14 found in the textbook *Cien años de identidad en la literatura latinoamericana del siglo xx* by Kelly Comfort (2018). The selection of texts to discuss on different forms of identities were the short story “La muñeca negra” by José Martí, the drama *El delantal blanco* by Sergio Vodanovic, the poem “La historia de mi cuerpo” by Judith Ortiz Cofer, the short stories “Axolotl” by Julio Cortázar, “La noche boca arriba” by Julio Cortázar, and the film *Fresa y chocolate* by Tomás Gutiérrez Alea y Juan Carlos Tabío.

3. Objectives

Academic programs pursue a highly engaging traditional undergraduate experience with emerging job markets and sustaining a thriving community outside of the classroom. The purpose of this study aims to reflect on how transformative pedagogies can bridge the Spanish language learning in these times to create social awareness and engage actively in the community by discussing different topics in a safe space. The objectives were, to identify, reflect and comment on:

- lived experiences related to race, social class, and colonialism.
- perceptions on social class, gender, and patriarchy in your community.
- different forms of prejudice when you move to another place.
- feeling trapped in small, new, or different spaces.
- sexual, religious, or political discrimination.

4. Methods

4.1. Participants

The sample size consisted of 16 participants of an online courses of Intermediate Latin American Literature, taking Spanish as part of their Minor or Major in Spanish from a public regional comprehensive institution in the South of Georgia, United States. The student's demographic makeup in 2024 was 49.40% White, 34.70 African American, 9.50 Hispanic, 3.50 Multiracial, 1.80% Asian, 0.20% American Indian or Alaska Native, 0.10% Hawaiian/Pacific Islander. The 16 course participants did not identify themselves by race or identity during the first discussion; nevertheless, class discussions were oriented towards ethnicity and race.

4.2. Data collection and analysis procedures

Data was collected anonymously as part of the essays completed at the end of the semester for Experiential Learning courses as part of the Quality Enhancement Plan (QEP-VSU2030) data at the end of the Fall 2024 semester.

Data was collected from reflective essays designed with three questions directed to soft skills that can be articulated or translated into different fields of study. As part of the Experiential Learning course, students complete a pre- and post-survey addressing different skills based on other courses and experiences. Additionally, at the end of the semester, students were asked to write an anonymous three-paragraph essay with at least 6 sentences in response to each prompt.

> Prompt #1, Did you develop a new understanding of your topic (on identity) as a result of this [discussion] activity? What about your values and perspectives? Did this activity [in the form of Circle of Voices] challenge your perspectives? If so, how?
>
> Prompt #2, Did you take the initiative for this activity? If so, how? What decision did you make with respect to the [discussion] activity? How were you held accountable for completing the activity on identity?
>
> Prompt #3, Did you experience growth intellectually, creatively, emotionally, socially, or physically as a result of the discussions? Please explain how this activity helped you to experience this growth. Were there any unexpected challenges or problems? If so, how did you overcome them?

Qualitative data were analyzed using interpretative analysis to identify patterns and perceptions on identity and the idea of engaging in dialogue with different students following the circle shape. The first step was asking the Assessment Committee Chair for the surveys. However, a sufficient date was not found. Only one student completed the survey. Essays, in contrast, were available. After reading comments, topics related to different forms of identity (ethnicity, race, class, gender, existentialist, temporal, spatial, political, and sexual) were identified.

5. Discussion

After the descriptive-interpretive analysis focused on lived experiences in the circle of voices before the readings, and guided self-reflections with open-ended prompts, different forms of identity were discussed. The discussions and self-reflections around identity reflect how questions were asked on identity. Participants identify how they gained awareness of everyday life social constructs on other cultures and within their own culture.

5.1. Circle of voices

This study examined how college Spanish students perceived themselves and others. The emphasis on connecting literary narratives with students lived experiences aligns with transformative learning and experiential learning theory in the sense that it is not enough to gain awareness but to self-reflect and engage in dialogues with the Hispanic/Latinx community. Discussions on how different experiences of identity (ethnicity, race, class, gender, spatial, and political) also shape the participants' perceptions of these topics.

Students reported gaining awareness early in childhood on discrimination due to the lack of diversity awareness represented in many toys such as the title of the reading, "La muñeca negra" by José Martí. For example, one participant pointed out how toy companies were involved in the lack of diversity fostering discrimination in early childhood: ["Has proveído muchas opiniones interesantes y importantes en tu video. Cuando hablamos de discriminación y una falta de diversidad en muñecas, mencionaste que hay una falta en diversidad de típos de cuerpo. Es muy interesante que, en vez de incluir todos en muñecas, las compañías son tercas y trata de evitar diversidad en una manera que no beneficia nadie"]. Another

participant pointed out that today's dolls are more diverse and inclusive. Other participants reflected on childhood friends' connections by groups, [Para mi, yo aprendé sobre raza muy joven. Fui a una escuela predominantemente negra con algunos latinos. Había una clara división racial. La mayoría de la gente sólo hablaba y se hacía amiga de personas que se parecían a ellos]. Regarding social class, participants' opinions interconnected with social class, gender, and space. For example, women have rights comparing to other places in Latin America based on parents and family members stories.

Hope emerged while bridging the past and present. Ikeda (2017) adds: Hope is found in committing ourselves to vast goals and dreams – such a world without war and violence, a world where everyone can live in dignity. Participants recognized that gender politics as well as business companies and generations have different life conditions today than in the past. Nevertheless, other participants argued that women's rights have not progressed. One participant mentioned how women participate in protests and walks and nothing happens: ["Estoy de acuerdo con tu decepción sobre no se han mejorado los derechos de la mujeres. Tengo 39 años, y cuando era jovena (como 19 años), fui por una marcha en Washington DC por los derechos de las mujeres. Fue un gran evento, y todos estábamos muy motivadas por eso. Después de todo eso, pensé ¿cómo es posible que la actitud de este pais NO cambie? ¿Y cómo pordríamos retroceder en los 20 años desde esa marcha? Es una lástima que todavía estamos luchando este pelea."] Another participant added that it will happen when people and government change ["Creo que es injusto que los derechos de las mujeres hayan retrocedido y no hayan progresado. No creo que las clases sociales sean flexibles en este momento ni que puedan arreglarse fácilmente. La única manera de hacer cambios es si la gente y el gobierno hacen cambios"].

About space identity, the participants moved due to family jobs. Participants traveled to Latin American countries and to various places in the country. They recognized the importance of learning a language while they were abroad. Communication and learning about other cultures resonated familiar with a few readings. Engaging dialogue with different people fosters a broader view on other cultures. [Es importante hablar con personas que son menores, mayores, casadas, solas, con hijos, y más. Puedo tener una perspectiva más vasta esta manera]. On the other hand, frequent moving also was difficult when growing up. [Puedo entender que, viniendo de una familia de militares, se mudara con frecuencia. Me mudé una vez en mi infancia y fue difícil para mí. Tuve que hacer nuevos amigos y perdí contacto con todos mis viejos amigos. Esto fue antes de las redes sociales].

Participants expressed their thoughts on the guided questions for each reading as a pre-reading activity. However, the circle of voices' rule to reply to different people failed. One empirical problem was that most of them waited until the last minute to post a video. Therefore, participants missed the opportunity to comment on other participants' videos. In the use of the Spanish language, the focus was free writing in the replies.

5.2. Self-reflection essays

Self-reflection essays showed a deep awareness of soft skills. A few samples to exemplify were randomly classify on themes such as previous assumptions, new understanding, and connections with the language,

1) previous assumptions, "This project challenged my previous assumptions by highlighting the complexity of social hierarchies and the multiple layers of discrimination that can exist."

2) new understanding, "Through the works we studied and our discussions in the Circle of Voices, I gained a new understanding of the struggles women have faced and continue to face, both historically and in contemporary society." "I definitely developed new understandings of these topics and made me take a deeper dive into my personal values and beliefs." "As a result, I now understand the importance of considering multiple dimensions of identity when analyzing social issues."

3) connections (language, participants, literary texts), "Engaging in dialogue with the "crítica literaria" and the texts themselves helped me connect these narratives to my own background and experiences, fostering a deeper understanding of the complexities of gender and identity." "They provided a safe and supportive space to explore different perspectives, challenge my own assumptions, and connect my personal experiences with the broader themes explored in literature." "I especially appreciated being able to hear what others had to say about the specific topics and having an open discussion with my peers. Being professional and having these conversations better prepares us for the "real world" especially with the use of Spanish."

Participants discussed the lack of engagement and engagement in online settings, "As with most online courses, interaction with everyone is quite stunted: only so much discussion can occur in the digital world. I do not know how to improve that." Brookfield & Preskill (2005) advised that the circle of voices could also be a frustrating experience.

They also reflected on the impact beyond the classroom and the contributions in their own communities. One participant said: "As a result of this experience, I am excited to find ways to incorporate more diverse stories in my classroom, to read with my students and listen to their opinions about the text."

6. Conclusion

Overall, the circle of voices technique was a safe space to talk about different topics that usually are silent. The most common were discrimination and gender. Identifying different forms of identity following the Kolb's stages, facilitated observation, and self-reflection to bridge the past with the present, the individual experiences of childhood, family, friends, and the topics narrated in different literary forms such as short stories, poems, drama, and film. The simulation of a circle of voices was reflected among those participants who created a dialogical rhythm. Dialogue on how lived experiences shape identities allowed an opportunity to reflect on how to foster a global citizenship identity when sometimes there is no hope and that nothing changes. Experiential learning teaching and learning techniques bridge knowledge with lived experiences and constant self-reflection. Transformative pedagogies allow us to create value for challenging situations and obstacles by engaging in a dialogue, by expressing themselves, and by listening to others. As future leaders, world languages (Spanish) students in higher education self-reflected in different forms of identity to further their knowledge and engage with other cultures.

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EXPLORING TEACHERS' SELF-EFFICACY FOR INCLUSION THROUGH A TUTOR-AI ASSISTANT: A PRELIMINARY EXPERT VALIDATION STUDY

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Abstract

Teachers' self-efficacy for inclusion is fundamental to the implementation of inclusive educational practices, shaping their ability to manage diversity, engage in reflective practice, and maintain professional agency. Within a socio-cognitive framework, the present study describes the design and preliminary expert validation of a Tutor-AI Assistant designed to enhance teachers' self-efficacy for inclusion through guided reflection. The digital tutor is based on Bandura's theory of self-efficacy and is organized around its four sources/modules: mastery experiences, vicarious experiences, social persuasion, and emotional and physiological states. A design-oriented methodology was employed, followed by an expert validation phase with five pedagogical experts specializing in teacher education and inclusive education. After testing the tutor, experts participated in semi-structured interviews, which were subsequently analyzed using thematic analysis (Braun and Clarke, 2006, 2022). The analysis revealed three overarching themes: theoretical and methodological coherence, which underscores the tutor's strong conceptual foundation and pedagogical clarity; usability, which highlights the significance of accessible language and practical integration into teachers' routines; and the reflective dimension, identified as the primary strength of the tool in promoting metacognitive awareness and professional self-reflection. Overall, the findings indicate that the Tutor-AI Assistant is a promising reflective tool for supporting teacher professional development. These results will guide further refinement and support future empirical testing with in-service teachers to evaluate their impact on self-efficacy for inclusive practices.

Keywords: *Teachers' self-efficacy, inclusion, Tutor-AI assistant, reflective practice, teacher professional development.*

1. Introduction

Inclusive education has become a global priority, aiming to ensure that all students participate fully in learning and school life (UNESCO, 1994, 2005). Although research demonstrates significant benefits for the educational community, the effectiveness of inclusion is largely determined by teachers' beliefs, training, motivation, and particularly their self-efficacy (Ainscow & Miles, 2008; Cerna et al., 2021; Hardy & Woodcock, 2015).

Self-efficacy is rooted in Bandura's Social Cognitive Theory (SCT), which provides a comprehensive framework for understanding human behavior through reciprocal interactions among personal, behavioral, and environmental factors (Bandura, 1986). Within this framework, self-efficacy is defined as confidence in one's ability to perform actions required to achieve specific goals (Bandura, 1977; Cameron and Grant, 2017). It encompasses intentionality, foresight, self-activity, and self-reflection, which refer respectively to forming intentions and plans, anticipating outcomes and guiding behavior, motivating and regulating actions, and reflecting on abilities to make informed choices (Bandura, 1986; Bandura, 2001). These capabilities enable individuals, including teachers, to plan, act, monitor, and adjust their behavior in dynamic social contexts, which are essential skills in inclusive educational environments (Pantić and Florian, 2015; Li and Ruppar, 2021). Self-efficacy is developed through four primary sources: mastery experiences, vicarious experiences (social modeling), verbal persuasion, and physiological and emotional states (Bandura, 2012).

In the context of inclusive education, scholarly attention to self-efficacy has increased, particularly regarding teachers' self-efficacy for inclusion. This construct refers to teachers' confidence in managing classroom diversity, which is shaped by experience, observation, encouragement, and emotional regulation (Wray et al., 2022; Yada et al., 2022; Woodcock et al., 2022; Herzig Johnson, 2023). Teachers' self-efficacy for inclusion directly influences their instructional strategies and resilience when facing challenges (Flores and Day, 2006). Furthermore, greater belief in their ability to teach all students is associated with more inclusive teaching practices (Gülsün et al., 2023).

1.1. AI in inclusive education

Recent years have seen a growing international interest in the use of artificial intelligence (AI) in education, particularly for teacher training and the development of reflective and self-regulatory skills. Intelligent Tutoring Systems (ITS) and educational chatbots provide personalized, adaptive learning experiences that enhance motivation and confidence (Lampropoulos, 2025; Pernaa et al., 2024). Meta-analyses confirm that these systems improve both cognitive and emotional outcomes by providing immediate feedback and realistic simulations that foster teacher reflection and self-efficacy (Chernikova et al., 2020; Létourneau et al., 2025). New generative AI models enable interaction with adaptive virtual tutors, providing formative feedback and supporting deliberate, reflective practice, both of which are key to developing self-efficacy (Bandura, 1997, 2001; Mollick et al., 2024). Evidence indicates that AI is advancing in areas such as language, social interaction, problem-solving, and metacognition, making digital tutors valuable for supporting reflective and emotional growth (OECD, 2025). Studies indicate that combining human and AI tutors encourages more adaptive, conscious, and motivating learning (Holmes et al., 2023; Kaltenborn, 2021).

2. Design of the study

The present study adopts a design-oriented approach, focusing on developing a Tutor-AI Assistant grounded in Bandura's theory of self-efficacy. The design phase aimed to translate theoretical constructs into a structured reflective learning environment for teachers, prior to empirical testing with end users.

The study evaluated a prototype Tutor-AI Assistant, a reflective tutor designed to enhance teachers' self-efficacy in inclusive education. This digital tutor serves as a conversational environment that guides teachers through structured reflection on their professional experiences, drawing on four key sources of self-efficacy. It features four interactive modules: a mastery experience that helps teachers reflect on personal episodes of successful classroom management or inclusive practice; vicarious experience through the analysis of modeled cases of inclusive teaching drawn from real contexts; social persuasion that provides teachers with the opportunity to reflect on the importance of positive and constructive feedback about their daily work as teachers, and also in relation to the tasks performed by students; physiological and emotional states that reflects on the emotional dimension of inclusive teaching, recognizing stressors, sources of satisfaction, and coping strategies. By structuring the reflective process around these four sources, the tutor translates an abstract psychological theory into a concrete psycho-pedagogical experience. Each module supports teachers' metacognitive awareness and emotional insight, fostering a holistic sense of self-efficacy that encompasses cognitive, affective, and behavioral dimensions.

3. Objectives

This study examines the preliminary pedagogical validity of a Tutor-AI Assistant designed to enhance teachers' self-efficacy for inclusive education, with a focus on expert validation prior to broader implementation. The objectives are to: assess the tutor's theoretical and pedagogical coherence, especially its alignment with Bandura's self-efficacy framework and inclusive pedagogy; investigate experts' views on its potential to encourage metacognitive awareness, professional self-reflection, and a non-judgmental approach; and identify key factors for effective use, such as usability, integration into blended professional development, and sustainability in teachers' routines. The ultimate aim is to inform further refinement of the tutor and guide future research into its impact on inclusive teaching practices.

4. Methods

4.1. Participants

Five pedagogical experts were purposefully selected for the study based on the following criteria: they held academic positions in pedagogy, educational psychology, or teacher education; had research expertise in inclusive education, teacher training, or digital learning innovation; and had direct experience in designing or mentoring professional development for teachers. All experts were affiliated with Italian universities and represented diverse pedagogical perspectives and institutional contexts.

4.2. Procedure

Data were collected through semi-structured interviews. Each interview was guided by a flexible protocol structured around three thematic clusters:

- Theoretical and pedagogical coherence – experts were asked to assess whether the tutor accurately translated Bandura's self-efficacy framework and aligned with principles of inclusive education.
- Design and usability – discussion focused on the clarity, tone, and accessibility of the tutor's language, the appropriateness of the digital format, and potential barriers for teachers.
- Perceived strengths and areas for improvement – participants reflected on the tutor's potential educational impact, suggesting refinements or future directions.

The interviews were conducted individually, in person, depending on participants' preferences, immediately after each expert had tested the Tutor-AI Assistant tool modules. Participants were encouraged to elaborate freely, provide examples, and share critical reflections. This approach allowed us to gather both confirmatory and emerging insights.

4.3. Data analysis

Data were analyzed using thematic analysis, following a reflexive and theoretically driven approach as outlined by Braun and Clarke (2006, 2022). This method was selected for its flexibility and suitability for exploring patterns of meaning across expert narratives while maintaining alignment with an explicit theoretical framework.

Following this approach, the authors familiarized themselves with the data through an initial exploration of the experts' narratives, consisting of an individual reading of the transcripts accompanied by note-taking. During the second reading of the transcripts, initial codes were generated based on the study's aims. These codes were revised by the first two authors and evolved not only with increasing knowledge of the text but also through comparisons among researchers. The initial themes were then generated, and, again, MG and FS engaged in a critical discussion to eliminate inconsistencies and to outline salient meanings that might be contained in each theme. These initial themes were subsequently revised in accordance with the criteria of internal homogeneity and external heterogeneity. For each theme, the extracts coded in the previous phase were reread to ensure consistency with the concept expressed in that theme; if they belonged to more than one theme, they were coded accordingly (i.e., twice or more, as necessary, for different themes). Once the inconsistencies between codes and themes were resolved and an agreement on coding was reached, the themes were named and defined.

5. Thematic synthesis of key findings

The thematic analysis of the expert interviews identified three overarching themes that capture pedagogical experts' evaluations of the Tutor-AI Assistant: theoretical and methodological dimensions, usability, and reflective dimensions. For details, see Table 1.

Table 1. Tutor-AI Assistant validity experience with experts' themes and subthemes found in our analysis.

	Theme	Code	Sub-theme	Definition	Who talks about it	N total turns
A	Theoretical and methodological dimension	A1	Solid structure	The interviews describe a solid modular and theoretical structure	I1, I3, I5	14
		A2	Methodological consistency	The interviews describe the clarity of the Tutor-AI Assistant with regard to the educational objective	I1, I4	4
		A3	Informative meeting	The interviews describe the need to schedule a preliminary informational and training meeting on the use of the Tutor-AI Assistant	I1, I2, I5	14
		A4	Final group meeting	The interviews describe the need to schedule a final group meeting as an opportunity for teachers to share their experiences with the Tuutor-AI Assistant and exchange best practices among themselves	I2, I3, I4, I5	34
		A5	Collection and analysis of quali-quantitative data	The interviews describe the need to collect and analyse qualitative and quantitative data	I1, I2, I4	31
		A6	Supportive tool	The interviews describe the supportive rather than substitutive value of the Tutor-AI Assistant for teachers' professionalism	I1, I4	6
B	Usability	B1	Plain language	The interviews describe that the Tutor-AI Assistant tool uses simple and clear language	I2, I4	9
		B2	Usage times	The interviews describe the need to assess the feasibility of the timing for using the Tutor-AI Assistant tool	I1, I5	17
		B3	Innovative potential	The interviews describe the innovative potential of the Tutor-AI Assistant tool	I1, I5	7
C	Reflective dimension	C1	Reflective tool	The interviews describe the reflective value of the Tutor-AI Assistant	I2, I3, I5	16
		C2	Reflective sheets	The interviews describe the worksheets that can be downloaded at the end of each module as useful for reflective continuity	I1, I3	10

6. Discussion

The present study aimed to explore the preliminary pedagogical validity of a Tutor-AI Assistant designed to enhance teachers' self-efficacy for inclusive education through guided reflection.

First, experts' emphasis on the tutor's theoretical and methodological consistency underscores the importance of grounding digital innovations in robust psychological and pedagogical frameworks. The perceived alignment between the tutor's modular structure and Bandura's sources of self-efficacy suggests that socio-cognitive constructs can be meaningfully translated into concrete, reflective experiences. This finding is consistent with previous research indicating that professional learning interventions are more likely to promote self-efficacy when they are theoretically explicit and experience-based (Bandura, 1997; Tschannen-Moran & Woolfolk Hoy, 2001). Furthermore, the experts' insistence on placing the tutor within a broader training programme, which includes preparatory and collective moments, emphasises the importance of avoiding a purely technocentric approach and reinforces the view of AI as a support rather than a substitute for human professional judgement.

Secondly, the issue of usability highlights a fundamental balance between innovation and feasibility. Although experts appreciated the innovative potential of using AI for reflective rather than didactic purposes, they also emphasised that accessibility, clarity of language, and compatibility with teachers' workloads are essential conditions for its adoption. This aligns with studies indicating that the effectiveness of digital tools in teacher training depends not only on their pedagogical value but also on their perceived practicality and sustainability in everyday professional contexts (Holmes et al., 2023; OECD, 2023). From this perspective, usability also emerges as an ethical and practical issue, as overly complex or time-consuming tools can burden such digital experiences, reducing the potential benefits and innovation of the tool.

Third, and most prominently, experts consistently identified the reflective dimension as the core pedagogical strength of the Tutor-AI Assistant. The tutor was perceived as a space that encourages teachers to pause, revisit their experiences, and engage in metacognitive reflection, processes that are often marginalized in fast-paced school environments. This finding aligns with models of reflective practice that emphasize the role of guided narration and structured self-analysis in professional learning (Korthagen, 2017). Importantly, the experts' appreciation of reflective worksheets and continuity tools suggests that reflection is most effective when it extends beyond isolated digital interactions and becomes part of an ongoing reflective cycle. In this sense, the tutor may function as a catalyst for reflective agency, supporting teachers in recognizing and consolidating their sense of professional competence.

Taken together, these findings suggest that AI-based reflective tutors hold promise as mediating tools for fostering teachers' self-efficacy for inclusion, provided that they are theoretically grounded, usable, and embedded within relational and institutional contexts. The expert validation also highlights the need to conceptualize AI not as an autonomous training solution, but as part of a blended reflective ecology that integrates individual, collective, and contextual dimensions of professional development.

7. Conclusions

The preliminary results of the study recognise the potential of the designed tool, the Tutor-AI Assistant, as a reflective practice in teacher training to improve their self-efficacy towards inclusion. The perspectives presented here reflect the assessments of experts in education and school inclusion. These considerations will inform the next phase of empirical testing with in-service teachers, using mixed methods to examine both perceived and measured changes in self-efficacy over time.

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SEAMLESS COLLABORATION IN DISTANCE LEARNING: EXPLORING THE ROLE OF AN EMBEDDED VIDEO-CONFERENCING-SYSTEM IN GROUP WORK

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Abstract

Collaborative learning is a cornerstone of modern education, offering significant academic, social, and psychological benefits. However, effective group work in distance learning environments remains challenging, particularly when it comes to fostering seamless communication and collaboration. This study investigates the integration of an embedded video conferencing system within a collaborative writing platform to enhance group work in a distance learning context. Using a mixed-methods approach, we examined how students utilized the system and explored the communication dynamics and social interactions that emerged during collaborative tasks. Data were collected from 353 students enrolled in a bachelor's-level psychology course, who participated in group writing tasks using the platform. Results revealed that while the system was frequently used for task-oriented activities such as organizing group work and discussing course content, its adoption for social interactions was limited. Sentiment analysis of video conferences indicated a neutral to slightly positive tone. Among 4,646 coded utterances, mean sentiment polarity was 0.12 and subjectivity 0.05, confirming task-focused, neutral-to-positive discourse with highly objective discussions focused on academic tasks. These findings suggest that while the embedded system effectively supports task-focused collaboration, additional features may be needed to foster social engagement and interpersonal connections. The study highlights the importance of designing collaborative tools that balance academic functionality with social interaction, offering valuable insights for educators and developers aiming to optimize virtual learning environments. Future research should explore broader applications of the system across disciplines and investigate strategies to enhance user acceptance and engagement.

Keywords: *Video conferencing system, virtual collaboration, cooperative learning, distance learning, learning technology.*

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1. Introduction

Research has demonstrated that successful group work in educational settings achieves better learning outcomes compared to individual work (Tsay & Brady, 2010). For instance, solving group tasks has been proven to enhance social competencies by fostering a sense of community, easing group dynamics, building mutual understanding, and creating a support system. It also offers psychological benefits, such as reducing anxiety about collaboration, increasing self-esteem, and fostering positive attitudes toward peers and instructors. Academic benefits are significant, as collaborative learning enhances critical thinking skills, engages learners in the learning process, improves course outcomes, provides a more personalized and adaptable teaching approach, and increases motivation among learners (Laal & Ghodsi, 2012). Despite these advantages, students do not always cooperate effectively in collaborative learning or group work settings (Gillies, 2016). As a student, it is important to regularly interact with other group members to promote mutual understanding and address potential social issues (Laal & Ghodsi, 2012; Johnson et al., 1985). However, without the right support, this can easily be overlooked. This is particularly problematic in distance learning environments, where students do not meet in person. Therefore, it is important to provide students with multiple virtual communication channels so that they can communicate as naturally and seamlessly as they would in a traditional, face-to-face university setting.

At universities, external tools such as forums, wikis, Zoom, and others are frequently utilized (University of Jena, n.d.; University Computing Centre Heidelberg, 2025; University of Hohenheim, n.d.). While a variety of tools are often provided to facilitate communication, they are not always integrated into a single environment. This can require users to switch back and forth between different platforms. The

freedom for students to choose their own tools can sometimes lead to the exclusion of group members, as not everyone may be comfortable or familiar with the selected tools. Additionally, the effort required to coordinate and search for suitable tools can be significant and may disrupt the group's workflow (Grudin & Poltrock, 1989). Furthermore, as switching tools can disrupt the workflow and "zone" in which learners are most effective (Csikszentmihalyi et al., 2018), it can pull them out of this state and thereby negate the positive effect. Therefore, it is advisable to provide predefined tools to avoid such barriers. However, a potential drawback is that this approach may isolate the group from other collaborative activities, so it is important to consider whether students will accept these tools.

To assist students in successfully completing group work, various tools have been developed and implemented. For example, the collaborative writing platform developed by Burchart and Haake (2024) supports teachers in setting up and monitoring collaborative writing tasks performed by large numbers of student groups. Here, students collaboratively work on documents both, synchronously and asynchronously to solve a group task. The platform provides a shared workspace for each group, featuring a shared text editor, a text chat, and a comment function on the shared documents for asynchronous communication. To further support synchronous communication among group members, this shared workspace (Burchart & Haake, 2024) has been expanded to include a video conferencing system named T^3 (Kasakowskij & Haake, 2025). This system is embedded within the collaborative writing platform, eliminating barriers such as additional logins or switching to third-party tools. It also provides features such as generating transcripts of group discussions, session summaries, and summary cards to facilitate reflection on conversations. The tool offers a wide range of options for asynchronous and synchronous collaboration and communication. However, it is unclear how students will use and accept such an all-round collaboration tool. Therefor the following research questions were formulated:

RQ1: How do students utilize the embedded video conference system in the collaborative writing task?

RQ2: What communication dynamics and social interactions emerge among students when using the embedded video conference system during collaborative tasks?

2. Method

For the study, a bachelor's-level psychology course in winter term 2024 which took place from October 1st, 2024 to December 31st, 2024 was selected. Participants volunteered to use a Moodle (Moodle HQ, 2025) Learning Management System (LMS) equipped with the collaborative writing platform (Burchart & Haake, 2024) as well as the embedded video conferencing system and agreed to participate in the study by signing a consent form. The study was approved in advance by the university's data protection officer. Students were informed about the use and handling of their data, and only anonymized data was used for analysis.

2.1. Study environment

A required group writing task structured the course. Students were assigned to groups of eight, each with a dedicated shared workspace containing a text editor, chat, and an embedded video conferencing system that automatically started a session when multiple members were present. The course unfolded in three phases:

Phase 1 (Preparation): Teachers configured the task, formed groups, and defined instructions and materials. A plug-in then automatically created the virtual group workspaces.

Phase 2 (Collaborative Writing): Students collaborated on writing and peer review within their workspace. Teachers monitored interactions and provided feedback via the integrated system.

Phase 3 (Assessment): Teachers graded the final products and provided summative feedback. Formative feedback and analysis of group dynamics were supported by data collected throughout the process.

This phased design provided a scalable, integrated framework for collaboration, monitoring, and assessment.

2.2. Data collection & analyzation

A voluntary online survey, accessible from December 16, 2024, to January 19, 2024, was used to gauge perceived system quality and acceptance. Participants responded to items on 7-point Likert scales, and results were analyzed using the median and interquartile range (IQR).

The survey design was based on TAM (Davis, 1989) and the Information Service Evaluation (ISE) model (Schumann & Stock, 2014), which holistically evaluates information services across five dimensions. This study concentrated on Dimension 3, Information Acceptance, evaluating aspects like system usage, adaptation, and influence.

To analyze the subjectivity and polarity of sentiments expressed during video conferences, audio streams were transmitted to a server in real-time while the system was in use. The server utilized OpenData's Whisper (Radford et al., 2023) and Voice Activity Detection (VAD) (Silero Team, 2021) functions to segment the audio streams and transcribe them into text fragments. Each speaker's audio stream was processed individually. The transcribed text fragments were reconstructed into complete sentences and statements, with a pause of more than 10 seconds used to demarcate the end of a statement. Finally, the reconstructed statements were analyzed for sentiment polarity and subjectivity using the Python Natural Language Processing (NLP) package TextBlob (Loria, 2018). This approach allowed for a systematic evaluation of the emotional tone and subjective content of the discussions.

3. Results

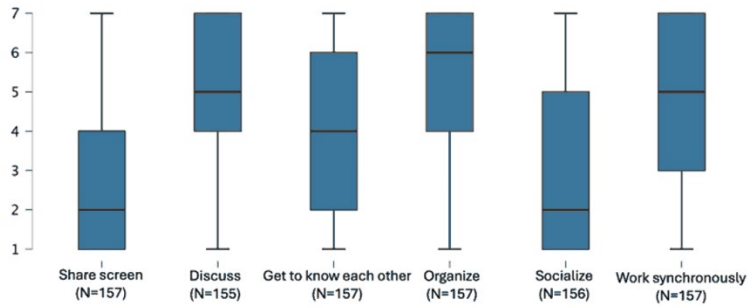
A total of 353 students from 102 working groups took part in the survey. The data collected demonstrated excellent internal consistency, as indicated by a Cronbach's alpha value of $\alpha > 0.9$. 84% (N=267) of the students were female, 15% (N=49) male and 1% (N=4) non-binary.

3.1. Online survey

The frequency of system usage varied significantly among participants. A majority of students (n = 187) reported that they never used the system. A smaller but notable group (n = 101) indicated using the system approximately once a month, while 36 students reported using it several times a month. Only 20 students stated that they used the system once a week, and a single student reported using it several times a week with their group.

Figure 1 illustrates the diverse ways in which students used and adapted the service. The system was rarely used for screen sharing, with a median score of 2 and an interquartile range (IQR) of 3, and for socializing within the group, with a median of 2 and an IQR of 4. It was occasionally used for getting to know each other within the group, with a median of 4 and an IQR of 4. In contrast, the system was frequently used for discussing course content, with a median of 5 and an IQR of 3, and for working synchronously on group tasks, with a median of 5 and an IQR of 4. The system was most often used for organizing group work, with a median of 6 and an IQR of 3.

Figure 1. Use and adaptation of the service.



3.2. Communication dynamics & social interactions

Over the course of the study, 253 students participated in at least one group session using the video conferencing tool and contributed verbal input. This resulted in a total of 4,646 statements, which were subsequently analyzed for sentiment using the Python NLP package TextBlob (Loria, 2018).

Figure 2. Subjectivity.

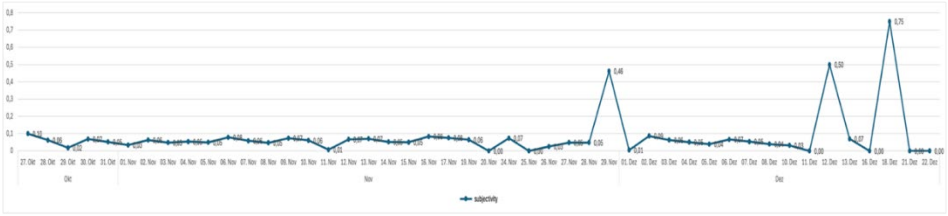


Figure 2 illustrates the measured average subjectivity values of all conversations per day. The values range between 0 and 1, where 0 indicates high objectivity and 1 indicates high subjectivity. As shown, the values remained consistently low throughout the study period, with only three outliers observed

on November 29, December 12, and December 18. Notably, the subjectivity values did not exceed 0.1 on most days, indicating a very low level of subjectivity in the discussions. Overall, the conversations exhibited a mean subjectivity value of 0.05, reflecting a highly objective tone.

Figure 3. Sentiment.

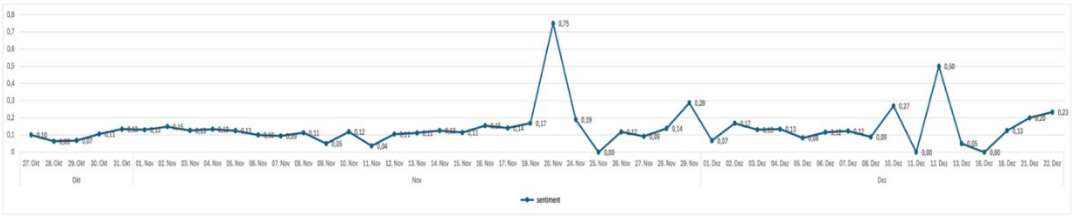


Figure 3 displays the measured average sentiment polarity values of all conversations per day. The values range between -1 and 1, where -1 indicates highly negative sentiment and 1 indicates highly positive sentiment. As depicted, the polarity values remained predominantly between 0 and 0.3 throughout the study period, with no negative mean polarities observed. Two outliers with higher sentiment polarity were noted on November 20 and December 12. On average, daily conversations among students were neutral to slightly positive. Overall, the conversations exhibited a mean sentiment polarity of 0.12, indicating a generally neutral to mildly positive tone.

4. Discussion & conclusion

The findings of this study provide valuable insights into the utilization and acceptance of an embedded video conferencing system within a collaborative writing platform in a distance learning environment. The results highlight both the potential benefits and challenges associated with integrating synchronous communication tools into virtual learning spaces.

- *Utilization of the Embedded Video Conferencing System (RQ1)*

The survey results revealed a mixed pattern of system usage among students. While a significant majority (n = 187) reported never using the system, a notable subset of students (n = 158) engaged with it regularly, particularly for task-oriented activities such as organizing group work (median = 6, IQR = 3) and discussing course content (median = 5, IQR = 3). This suggests that the system was most effective when aligned with specific academic tasks, rather than for social or informal interactions. The low usage for screen sharing (median = 2, IQR = 3) and socializing (median = 2, IQR = 4) further underscores the importance of designing tools that cater to the functional needs of students in collaborative learning environments. Low adoption may stem from unfamiliarity, a preference for external tools (e.g., Zoom), or perceived limitations in flexibility despite integrated access. This aligns with research stating technology adoption depends on ease of use, workflow compatibility, and user preferences (Al-Ahdal et al.; Grudin & Poltrock, 1989).

- *Communication Dynamics and Social Interactions (RQ2)*

Sentiment and subjectivity analysis showed a neutral to slightly positive tone (mean polarity=0.12, mean subjectivity=0.05), confirming use for objective, task-focused communication, not social or emotional discourse. This matches survey data and underscores the need to foster both task and social interactions for group cohesion and learning outcomes (Laal & Ghodsi, 2012; Johnson et al., 1985). Future systems could add features like virtual breakout rooms to encourage informal interaction.

The study highlights the need for tools addressing both academic and social dimensions. While integration reduced technical barriers, acceptance was limited by perceived utility and user preferences. To improve adoption, designers could add customizable features, real-time feedback mechanisms (e.g., session summaries), and elements to boost engagement such as gamification (Pura, 2022), AI-enhanced interfaces (Rajaram et al., 2024), or social community-building features (Porwol et al., 2022; Manuel, 2022). As the ISE model notes (Schumann & Stock, 2014), service quality depends on interconnected dimensions like user characteristics and the information environment, warranting further study.

Limitations include potential selection bias from voluntary surveys, and limited generalizability due to a single-course focus. Reliance on self-reported data and automated sentiment analysis may miss nuances; future work should use qualitative methods (e.g., interviews) across multiple disciplines.

In conclusion, this study demonstrates the potential of embedded video conferencing systems to support collaborative learning in distance education, particularly for task-oriented activities. However, mixed usage and limited social engagement call for more nuanced design. By addressing the functional and social needs of students, fostering a supportive information environment, and continuously evaluating and

refining the system based on user feedback, educators and designers can create more effective and engaging collaborative learning experiences. Future research should build on these findings to explore additional dimensions of technology acceptance and identify strategies for enhancing the adoption and impact of collaborative learning tools in diverse educational contexts.

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IDENTIFYING THE DROP-OUT DECISION MOMENT IN PROGRAMMING MOOC STUDENT PROGRESS DATA

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Abstract

Although Massive Open Online Courses (MOOCs) on programming are considered a proven way of teaching this difficult subject to large audiences, they also suffer from high dropout rates, often exceeding 90%, which leads to ineffective allocation of instructors' effort, wasted on providing support to students who are not willing to finish the course anyway. This paper analyzes course progress data gathered from students attending a MOOC on introduction to programming in Python to pinpoint the course sections at which learners most often drop out as well as investigate the correlation between the students' performance at earlier course sections and their dropping out at the later sections. The key findings include: large differences in dropout rates among respective course sections; the lack of course sections that the students' low performance at which could be used as a good predictor of their later dropout; and the relatively high variety in the predictability of dropout at respective course sections depending on the students' performance at the earlier course sections. The findings bring practical implications for both MOOC developers and instructors.

Keywords: *Student dropout analysis, student dropout prediction, programming MOOC, MOOC management.*

1. Introduction

Massive Open Online Course (MOOC) is defined as "an online course open to anyone without restrictions, usually structured around a set of learning goals in an area of study, which often runs over a specific period of time on an online platform which allows interactive possibilities that facilitate the creation of a learning community" (EC, 2014, p. 2). The MOOC's advantages made it a highly popular form of distance learning, with over 220 million users worldwide having enrolled in at least one MOOC in 2024, according to a recent report (MGR, 2026). Although it has been confirmed that MOOC-based education is capable of significantly improving academic achievements and motivation (Wang and Li, 2022), it has a weak side, which consists in the high dropout rate (Huang, Jew, & Qi, 2023), which may be as high as 95% (Alghamdi, Soh, & Li, 2025, and works cited therein). Despite this phenomenon has been the subject of many versatile studies (Cișmașu, Cibu, Cotfas, & Delcea, 2025), there are many aspects that require further investigation. This paper contributes to this vein of research, taking into focus the example of a computer programming MOOC, and investigating students' progress in the course to reveal: the topical sections at which learners most often drop out and the potential relationships between students' low performance at specific course sections and their later drop-out decision.

2. Data and methods

2.1. Data source

The study is based on course progress data obtained from a MOOC on introduction to programming in Python 3 whose design and evaluation has been described in our earlier work (Swacha, 2021). The MOOC runs on the Open edX platform (Open edX, 2026) which provides access to individual grades attained by every student at the end of each course section. In the course, there are 14 modules, titled respectively: First contact with the Python language, Character strings, Programs, Sequences, Loops, Sets and dictionaries, Functions, Object-oriented programming, Python standard modules, Data processing, Algorithms in Python, Storage of data, Use of PYPI modules, and Python in practical applications.

Although as of February 2026 there is an eighth edition of the course ongoing, due to updates of the platform, which is maintained by a third party, access to a part of the student progress data has been lost. Consequently, we were able to retrieve complete data of two course editions only and one edition's partial data, altogether comprising 5542 registered participants.

2.2. Data preprocessing

As is the case with many other MOOCs, most of the participants leave the course early, not passing even its first section. While such cases can be interesting for research, e.g., in the context of zero-time dropout predictors (Swacha, Muszyńska, 2023), they are of no use to this study, which seeks to identify course sections where the students' performance at can be a good indicator of their later dropping out. Consequently, all records of such early dropouts have been removed from the database, leaving 1326 student records for the analysis; these include 974 students who dropped out before the final test. The overall dropout rate in the course dataset analyzed (including the early dropouts) was 87.5%.

2.3. Data analysis

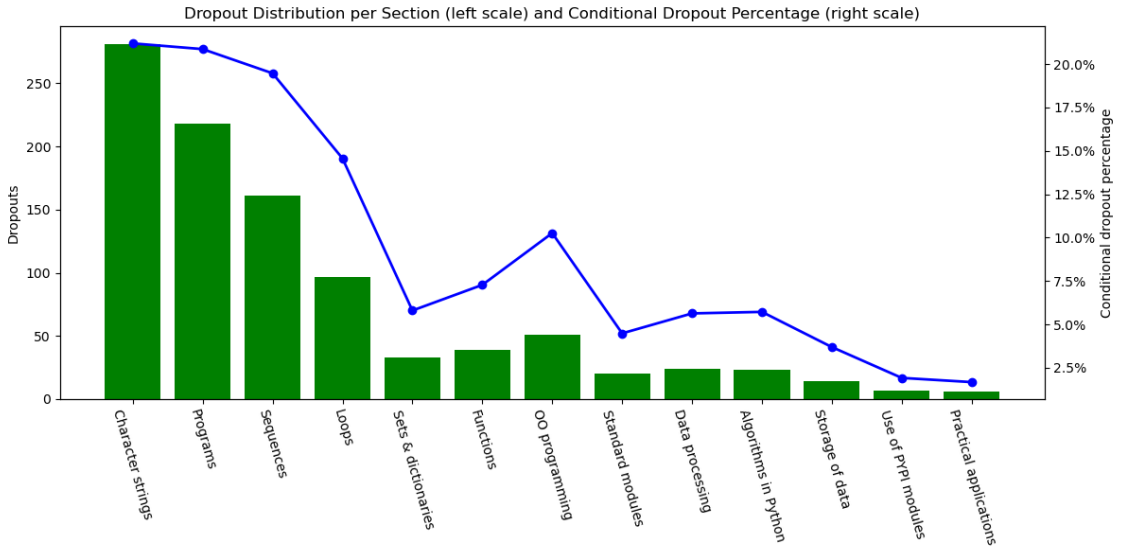
Data preprocessing and analysis have been performed using scripts written in the Python language. The main results were obtained using visual analysis of charts generated with the help of Python's Pyplot and Seaborn libraries. To visualize the heatmap, the Pearson correlation coefficient has been calculated using Python's Pandas library. The Python code for data preprocessing and visualization has been developed with the assistance of Microsoft Copilot.

3. Results

3.1. Dropouts per course section

Figure 1 presents bars indicating the number of students dropping out of the course at its specific sections and a line indicating the percentage of students dropping out at a specific section, considering only the students still remaining in the course at that point. Note that the chart begins with section 2 as the early dropouts (which happened at section 1) have been removed during data preprocessing (and their inclusion in the chart would make it unreadable due to the out-of-proportion number of early dropouts).

Figure 1. Number and percentage of dropouts per course section (covering sections 2-14).



As can be seen in Figure 1, the first five bars (representing course sections 2-6) follow a clearly decreasing pattern which can be caused by both the increasing difficulty of subsequent programming topics and the sufficient time spent in the course to realize it is not the right course for those who might have imagined it differently. The height of the remaining bars varies, which can be, at least to some extent, explained by the varied difficulty of the specific course sections. Note, e.g., the relatively high dropout percentage for the OO programming section and low for the Standard modules section.

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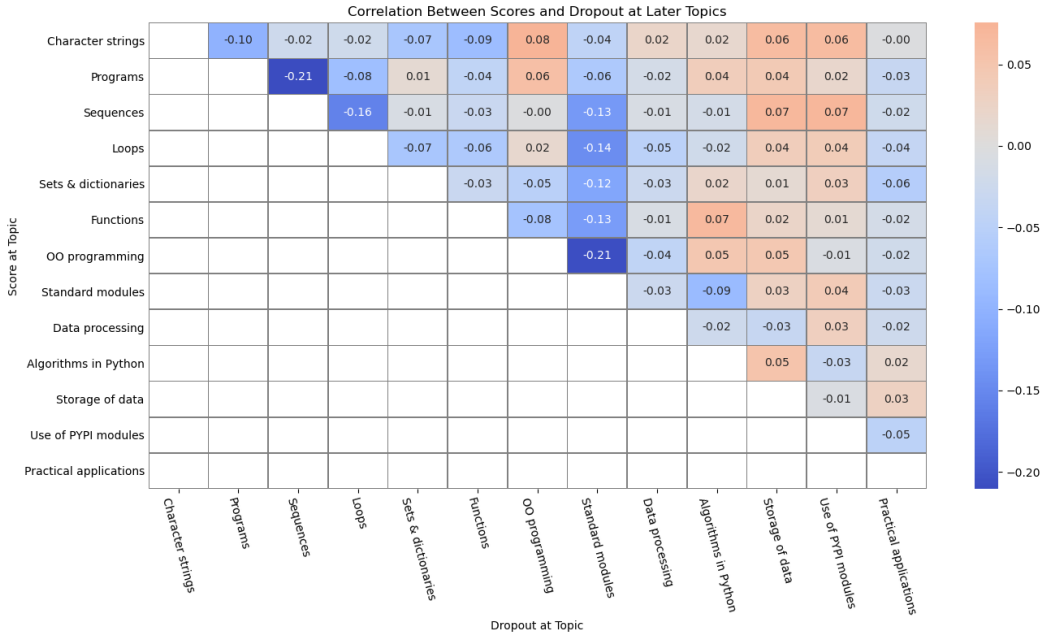
3.2. Course section performance vs. later dropouts

Figure 2 presents a heatmap showing the correlation between the score received by students in the test covering the respective course section's topical scope and the dropout happening at any of the later course sections. Note that negative correlation indicates that a higher score attained at a specific course section reduces dropout likelihood at the other section, whereas positive correlation indicates that a higher score attained at a specific course section increases dropout likelihood at the other section.

Figure 2. Correlation between students' learning effects at specific course section and dropout at a specific section.



While the level of correlation shown in Figure 2 is very weak in most cases, an unexpected observation can be made: that the patterns tend to form vertically, not horizontally. This means that despite the key idea motivating for the presented study was the expectation that there could be course topics the students' performance at which could indicate their higher probability of later dropout and no such cases were found in the analyzed data, instead, course topics have been identified the students' dropout at which could be better predicted by their performance at previous course sections (in the studied course: Loops, Functions, and Standard modules). Note that, considering also Figure 1, these are not course sections for which the dropout rate was particularly low or high (in which case, a simple explanation for this finding could be provided).

In contrast, negligible yet positive correlation is visible primarily in two columns corresponding to two late course sections: Storage of data and Use of PYPI modules. Such a counter-intuitive result suggests that dropout at these sections of the course is most probably not caused by their difficulty (as the students performing better in earlier course sections were slightly more prone to drop out at these sections).

4. Discussion

The study adds a new aspect to the prior research on MOOC dropout. While the earlier studies were focused on why the students drop out (Bezerra & Silva, 2017), this one strives to answer when it is most probable to happen. While the general trend of dropout percentage is decreasing with course progress, the results presented in section 3.1 clearly show its notable variation, most probably caused by the difference in difficulty of the respective course sections – itself confirmed by prior study on the number of students' solution submissions till one was accepted (Szydłowska, Miernik, Ignasiak, & Swacha, 2022). This provides a practical implication for MOOC course designers that they should avoid rapid changes in the difficulty of subsequent course sections, as it may lead to students dropping out.

More unexpected are the results presented in section 3.2. Regarding the very weak correlation, it must be noted that it is not contradictory to prior research (e.g., Panagiotakopoulos, Kotsiantis, Kostopoulos, Iatrellis, & Kameas, 2021) showing high correlation between assessment results and dropout, as those authors consider dropout anywhere in the course, not in a specific section later to the one at which the student's learning progress was assessed. While the results have not indicated course topics the students'

performance at which would be a particularly good predictor of their later dropout, they have indicated course topics the students' dropout at which could be predicted by students' performance at prior course sections easier than for other topics. This provides a clear practical implication for MOOC course instructors that they should identify such course sections and provide additional support for the low-performing students at those sections to reduce dropout risk.

5. Conclusions and future work

The study contributes both to the research on MOOC dropout, indicating that dropout predictability varies depending on course sections, and to the practice of managing MOOCs, for which it provides simple means for identifying course sections at which low-performing students are more prone to dropout and should then be given additional support.

We believe that this study will motivate further research to confirm the presented findings (using data from other courses) and put them in context (by interviewing students to identify their dropout motives). Another interesting direction of future work is investigating the factors that contributed to the dropout decision at specific course section, thus extending the vein of studies which investigated the factors that affect MOOC effectiveness (e.g., Yu, Xu, & Sukjairungwattana, 2024; Huang, & Qi, 2025).

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A CURRICULUM-ALIGNED SCREENING TOOL FOR IDENTIFYING MATHEMATICAL LEARNING DIFFICULTIES IN GRADE 3

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Abstract

This study focuses on the development and initial testing of a school-based mathematics screening tool intended to assess whether third-grade students have acquired the essential skills and knowledge required for a solid foundation in further mathematics learning and to identify children with mathematical learning difficulties. A quantitative empirical design was used to construct a curriculum-aligned assessment consisting of a written and oral component. Results indicate that approximately 5–8% of students demonstrated performance profiles consistent with MLD, with specific difficulties observed in multiplicative reasoning, unit conversion, and verbal description of geometric solids. The test was administered in five schools in Tallinn. A total of 251 students participated in the written assessment and 82 students in the oral assessment. Based on the analysis of the test results, it can be concluded that the test presented in this article offers an overview of students' attainment in mathematics. Furthermore, the results can be used by professionals working with children to plan and implement their work more effectively.

Keywords: *Mathematical learning difficulties, mathematics assessment, screening tool.*

1. Introduction

Mathematical difficulties can greatly hinder students' learning of the subject. While there is no exact statistics, it is suggested that around 25% of people struggle with mathematics (BDA, 2025). Other authors have proposed that approximately 5%–8% of children experience mathematical difficulties (Geary, 2004; Lyon, 1996; Reeve & Gray, 2015; Shalev & Gross-Tsur, 2001), yet these difficulties receive considerably less attention than writing and reading difficulties. These numbers indicate that there can be students in every grade and classroom needing extra support. Mathematical difficulties have an impact on the learning of all skills and topics in mathematics. Previous studies have found that these struggles are mostly caused by differences in cognitive processes (Huijsmans et al., 2022). In the next paragraphs, we will give an overview of how various areas of mathematics can be affected by these differences. Arithmetic skills refer to the ability to perform, understand, and accurately evaluate standard algorithms to solve a variety of tasks both mentally and in written form using different tools and strategies (Sharma, 2015). Arithmetic skills provide the foundation for learning higher level mathematics, beginning with algebra and geometry (Dowker, 2024; Sharma, 2015). In terms of arithmetic skills, students with mathematical learning difficulties differ from their peers, for example, in their ability to apply basic knowledge to solve simple computational and word problems (Dowker, 2024; Koç & Korkmaz, 2020). The use of basic knowledge does not develop efficiently in children with mathematical learning difficulties during the first stage of primary education (Shalev & Gross-Tsur, 2001). These children tend to rely on immature computation strategies and continue to make errors in counting (Stocker et al., 2018). The most pronounced difference between students with learning difficulties and their peers lies in the significantly slower rate at which necessary skills are acquired (Dowker, 2022, 2024; Geary, 2004, Rouselle & Noël, 2007). Many children with learning difficulties do not demonstrate readiness to shift from procedural problem-solving strategies to memory-based strategies, which suggests difficulties in storing relevant knowledge in long-term memory (Dowker, 2014). Several authors (Dowker, 2024; Geary, 2004; Rouselle & Noël, 2007) emphasize that students with mathematical learning difficulties perform less accurately and make larger errors than their peers when comparing Arabic numerals and given quantities. In addition to number sense and arithmetic, mathematical difficulties can also be apparent when solving word problems, or tasks related to geometry and measurement. Word problems present a multifaceted challenge that requires reading skill, text comprehension, understanding mathematical terms, composing arithmetic facts, and answering the problem with full sentences (Henderson, 2012). Geometry and measurement require visual-spacial thinking and accuracy, skills that can be challenging if the shortcomings of cognitive processes limit learning. In order for special educators, classroom teachers, and subject teachers to identify mathematical learning difficulties

as early as possible and to better plan and implement instruction, it is essential to have precise information about the skills that children have already acquired and the areas that present difficulties. The aim of this study was to develop an assessment instrument that evaluates the extent to which third-grade students have acquired the skills and knowledge necessary for a solid foundation for further learning in mathematics. The following research questions were established: 1) What are the strengths and weaknesses of grade 3 students in mathematics skills? 2) What are the mathematics skills of low performing and high performing students within oral assessment?

2. Method

2.1. Sample

The first sample for written assessment consisted of 251 students from grade 3 enrolled in five general education schools in the capital of the country (aged 9–10). Participation was voluntary, and schools and parents were informed about the purpose and procedure of the study prior to data collection via a signed consent form. Based on performance in the written assessment, a purposive subsample of 82 students was selected to participate in the oral assessment. Selection criteria for the oral assessment included A) students who scored 50% or less on the written test (N = 16), indicating potential risk for mathematical learning difficulties, and B) a comparison group of students with higher written test performance (N = 66), selected to ensure variability and to examine the added value of oral assessment across performance levels.

2.2. Data collection instrument and analysis

The data collection instrument was developed in alignment with national curriculum requirements for grade 3 mathematics and designed to be feasible for use in everyday school practice. The development process was informed by previous research on mathematical learning difficulties and by practical considerations relevant to classroom and support team contexts. The data collection instrument consisted of two parts: written and oral assessment. Both parts of the instrument assessed three core mathematical domains central to upper primary mathematics:

1. Arithmetic (calculation): including basic operations (addition, subtraction, multiplication, division), multi-step calculations, and understanding of relationships between operations.
2. Measurement and word problems: including length measurement, unit conversion, and application of arithmetic skills in contextualized problem-solving tasks.
3. Geometric figures and solids: including recognition, classification, and verbal description of two-dimensional shapes and three-dimensional solids.

While the written assessment of the instrument focused primarily on procedural accuracy and application, the oral part emphasized conceptual understanding, verbal reasoning, and the ability to explain mathematical ideas. Descriptive statistics indices were calculated to give an overview of the overall performance patterns, score distributions, and domain-specific results.

2.3. Data collection procedure

The written assessment was administered during regular school hours in classroom settings by the students' teachers or school staff, following standardized instructions. Students completed the written assessment within a fixed time frame of 45 minutes. The oral assessment was conducted individually in a quiet setting within the school environment. Each oral session followed a structured protocol and included tasks designed to elicit students' verbal explanations, reasoning strategies, and conceptual understanding. The two-stage assessment procedure was designed to minimize disruption to regular instruction while providing additional diagnostic insight into students who demonstrated weaker performance in the written assessment.

3. Results

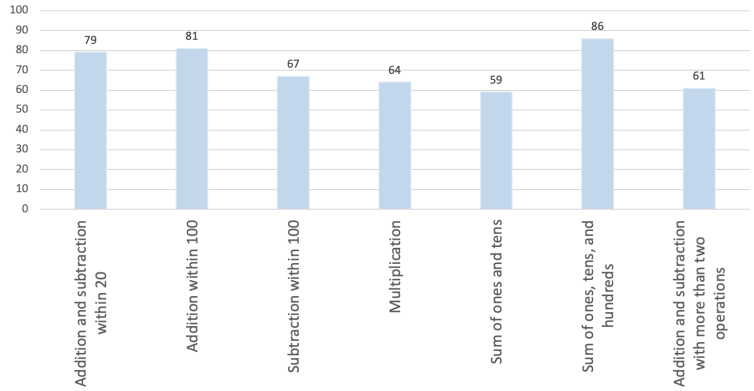
3.1. Strengths and weaknesses based on written assessment

The mean total score for the written assessment was approximately $M \approx 52$ ($SD = 10.45$; max = 67). A majority of students (42%) scored from 75% to 89% of the maximum score, while the remaining students achieved either more (23%) or less (35%). 16 students, which is around 6% of the whole sample, scored less than 50% of the whole test. None of the students completed the written assessment with zero errors, while four students solved the tasks in the written assessment with only one error. The lowest score was 13 points.

3.1.1. Arithmetic skill. Arithmetic skill was assessed within multiple sub-skills. Students were most successful in representing a three-digit number in sum of ones, tens, and hundreds (maximum score of 3

points was achieved by 86% of the participants; Figure 1). Controversially, representing a two-digit number in sum of ones and tens was the least successful sub-skill with 59% of students scoring the maximum. In terms of calculations the skill of addition within 100 appeared to be the strongest, while multiplication stands out as the most difficult.

Figure 1. Percentage of students achieving maximum points of respective sub-skill.



3.1.2. Measurement, geometric figures, and word problems. The skills of measurement and identifying geometric figures present very varied results. Firstly, students were the most successful in identifying triangles among a set of geometric shapes with 88% scoring maximum (Figure 2) and 12% failing to do so. In the task assessing the measurement and labelling of a line segment, 78% of the students achieved the maximum score of 3 points, while 19% failed to complete the task successfully. It should be noted that 4% of the students did not attempt the task. Among other sub-skills presented in Figure 1, the task involving comparison of line segments presented overall difficulty with only 18% of students receiving a maximum score of 5 points. 40% of students got half of the task correct and 22% of students fully failed to complete it. 7% decided not to even try solving the task. Other skills that are not well acquired are conversions of metres to decimetres and decimetres to centimetres with 20% of students scoring zero. Assessing measurement in centimetres and correct labelling of side lengths of geometric shapes was successfully solved by 43% of students, while 7% failed to solve the task. The students were most successful in solving one-step word problem involving addition with 77% of participants achieving the maximum score (Figure 3). The least successful operation in the context of word problem was subtraction. While the overall success rate looks promising, it is important to bring out that 27% of students failed to solve a single-step word problem using division, 38% using subtraction, and 23% using addition.

Figure 2. Percentage of students achieving maximum points of respective sub-skill.

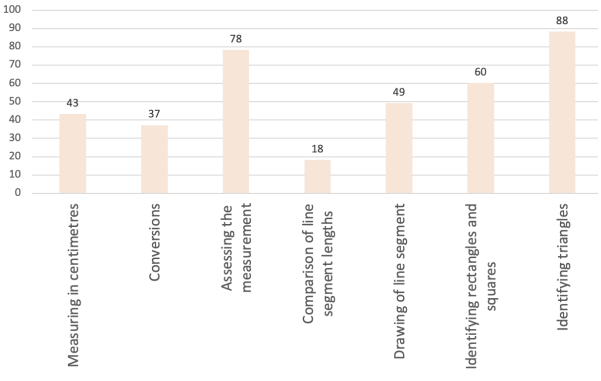
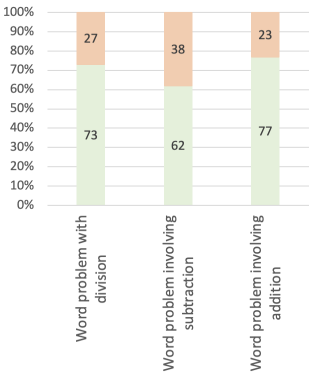


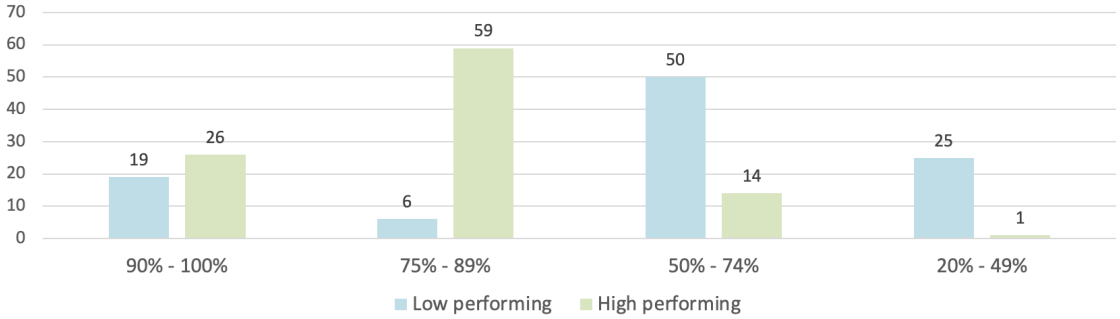
Figure 3. Percentage of students achieving maximum points (green columns) or failing to solve the task (orange columns) of respective word problem.



3.2. Oral assessment of low and high performing students

The oral assessment was administered to a purposive subsample of 82 students, including those identified as at risk based on written performance, as well as a comparison group of high performing students. The oral assessment confirmed the difficulties of students scoring less than 50% in the written assessment (low performing students). 99% of high performing students also got more than half correct in the oral assessment compared to 75% of low performing students.

Figure 4. Percentage of students falling into the respective percentage of the overall result of oral assessment.



The oral assessment also revealed important qualitative differences in students' mathematical understanding. While many students were able to produce correct answers in written form, the oral format exposed difficulties in verbal reasoning, explanation of strategies, and conceptual understanding. This was particularly evident in tasks involving geometric solids. Even students with relatively strong written performance often struggled to articulate properties of three-dimensional shapes accurately. These findings suggest that oral assessment provides critical information that may not be captured through written testing alone.

4. Discussion and practical implications

This study provided an overview of the strengths and weaknesses of grade 3 students in mathematics based on written assessment. It also emphasized the different performance of low and high performing students within oral assessment. The test was based on the basic mathematical skills and knowledge outlined in the 2011 National Curriculum for Basic Schools in Estonia, ensuring an accurate overview of the relevant topics in mathematics. The results of the study confirmed the fact presented in the introduction that mathematical learning difficulties occur in approximately 5%–8% of students (Geary, 2004; Lyon, 1996; Reeve & Gray, 2015; Shalev & Gross-Tsur, 2001). In the written test, 6% of the participants scored below 50% of the maximum possible score. The most challenging tasks in both the written and oral assessments were those related to the domains of geometry and measurement. In the written assessment, the lowest performance was observed in the task requiring students to compare the lengths of given and independently measured line segments. The results of the measurement and geometry tasks discussed above support the theoretical assumption that visually based spatial thinking, memory, and reasoning play a crucial role in mathematics, and that difficulties in these domains contribute to mathematical learning difficulties. The claim made by Vukovic and Siegel (2010) – that visuospatial processing based on visual perception is involved in the development of mathematical learning difficulties – is supported by the present findings. In contrast, Bugden and Ansari (2015) have argued that visually based perceptual difficulties occur only in children with severe mathematical learning difficulties. It is therefore worth noting that future research on mathematical learning difficulties should examine more closely how deficits in different cognitive functions affect the acquisition of geometry and measurement skills. Such knowledge would also be valuable for teachers and special educators in order to plan and organise instructional support for students more effectively. Surprisingly, the results of our study presented a rather good arithmetic skill among grade 3 students, with only multiplication showing the need for attention. However, it should be noted that multiplication is the least practiced skill in grade 3, while addition and subtraction are already covered through grades 1 and 2. The high percentage of accuracy can also be explained by a rather lengthy time frame for filling the written assessment. What is more, Chinn (2020) suggests to limit the time when measuring calculation skill – this way it is possible to distinguish the students who are more skilful, and have a certain automaticity and speed needed for solving more complex arithmetic tasks. A timed test does not, however, reveal calculation strategies and reasons for difficulty. To do so, written assessment is suggested to be combined with oral assessment.

4.1. Practical implications for teachers and support teams

The findings of this study have direct implications for classroom practice and for the work of school support teams. First, the screening tool offers teachers a structured and feasible method to identify students who may require additional support in mathematics at an early stage. If the instrument is aligned with curriculum content, it can be integrated into regular assessment practices without excessive time or resource demands. Second, the domain-specific results enable targeted instructional planning. Rather than relying on global performance indicators, teachers can use screening outcomes to focus on specific sub-skills, such as multiplicative reasoning, unit conversion, or spatial language related to geometric solids. This supports differentiated instruction and the design of tiered interventions tailored to students' actual learning needs (e.g., Malva et al., 2026). Third, oral assessment provides valuable information for

collaboration between classroom teachers, special education teachers, and other support specialists. Insights into students' verbal reasoning and conceptual understanding can inform decisions about instructional strategies, scaffolding, and the use of visual or manipulative supports. In this way, the screening tool functions not only as an identification instrument but also as a guide for pedagogical action.

4.2. Limitations and future directions

Several limitations should be acknowledged. The study was conducted using a convenience sample, which limits the generalizability of the findings. In addition, the absence of national norms restricts the ability to establish definitive cut-off scores for identifying students at risk of mathematical difficulties. The study also focused on descriptive analyses, consistent with its exploratory and practice-oriented aims, but limiting the opportunities for more profound findings focusing on the relationships of the variables or comparison of sample sub-groups. Future research should focus on extending psychometric evaluation, including reliability analyses and validation with larger and more diverse samples. Establishing normative data across different regions would strengthen the utility of the instrument and support its broader implementation. Further investigation into the predictive validity of the assessment, particularly its ability to identify students who benefit most from targeted interventions, would also be valuable.

4.3. Conclusion

In conclusion, this study demonstrates that a curriculum-aligned, school-based screening tool combining written and oral assessment can effectively support early identification of mathematics learning difficulties in grade 3. By providing teachers and support teams with practical, domain-specific information, the instrument contributes to more informed instructional planning and has the potential to improve educational outcomes for students at risk of persistent mathematics difficulties.

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PROMOTING EDUCATION AND CAREERS IN LOGISTICS THROUGH AN ONLINE PLATFORM CENTRED ON THE NEEDS OF TEACHERS AND STUDENTS

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Abstract

The logistics industry is undergoing considerable transformation due to three major trends: digitalisation, sustainability, and internationalisation. This requires employees to demonstrate not only the capacity to manage increasingly challenging tasks, but also a repertoire of subject-specific and interdisciplinary competencies, often referred to as "hybrid skills". However, the logistics industry is currently facing challenges due to a shortage of skilled workers and the significant need to motivate young people to pursue careers in the sector. Since 2016, the web platform "RETrans" offers quality-assured, free of charge information and teaching materials on transport logistics, primarily targeting teachers and aiming to raise interest for jobs in the logistics industry. The need to update the RETrans platform is driven by two key factors. Firstly, there have been significant changes in the logistics industry, which have necessitated an update to the platform to ensure it remains relevant. Secondly, the platform has specific potential for improvements to ensure its success in the long run. The present paper sets forth the findings of a thorough evaluation of the RETrans-platform with two objectives: firstly, to enhance the platform's quality and user base, and, secondly, to discern prospective directions that centre on ensuring its relevance in the future. The evaluation comprises an online survey among school students, a workshop with didactics and e-learning experts, workshops with teachers and logisticians, as well as a focus group with university students in logistics. The findings indicate that overall RETrans offers trustworthy information and excellent materials and some adaptions can even further improve its performance. Teaching materials should contain more didactic information, such as intended learning objectives and competencies, application scenarios, and specific teaching methods, to facilitate integration into specific curricula. There is also a lack of teaching materials that promote self-organised learning. Furthermore, the evaluation identifies room for improvements regarding the website's usability and aesthetics and reveals a strong need to include future-oriented topics such as sustainability, digitalisation, and internationalisation to address the dynamic competence requirements of the sector. The formulated recommendations act as guiding principles for the platform's redesign and may inspire similar initiatives in fields beyond logistics.

Keywords: *Logistics, skills shortage, promotion of careers, RETrans, RETrans4Future.*

1. Introduction

The transport industry is currently influenced by a complex interplay of environmental, technological, and social factors (Dorantes & Allen, 2024). The push for decarbonization and the move toward cleaner technologies (European Commission, 2025) are major drivers of change, as for instance the transition to electric vehicles. Whilst these trends have the potential to enhance efficiency, they also carry a risk of leading to job losses in low-skilled sectors (Dorantes & Allen, 2024). Actually, the logistics industry is confronted with a global shortage of qualified personnel at all occupational levels. The severity of this shortage varies significantly between regions and job categories: in developing and emerging regions, the most acute shortage is at the managerial level, whereas in developed regions, the primary challenge is finding enough staff for operational roles (McKinnon, Flöthmann, Hoberg, & Busch, 2017). It is reasonable to assume that the logistics industry will continue to depend heavily on the skills and abilities of its workforce. Therefore, the performance of companies and countries in this sector is significantly influenced by the quantity and quality of the available workforce (McKinnon, Hoberg, Petersen & Busch, 2024). Consequently, the industry requires employees to demonstrate not only the

capacity to manage increasingly challenging tasks, but also a repertoire of subject-specific and interdisciplinary competencies, often referred to as "hybrid skills" (Kohl, 2023). In view of this, the logistics industry is currently facing the significant challenge of motivating young people to pursue careers in the sector (Eitler & Schodl, 2023).

In order to enhance the appeal of the logistics and transport sector to young people, according to McKinnon, Flöthmann, Hoberg & Busch (2017) it is recommended that the sector emphasises its crucial role in addressing its comparatively low prestige. Logistics companies could adjust salaries and benefits (Crotty & Morgan, 2023) to compete with other sectors, such as manufacturing or finance. Improving the work environment and the work-life balance could also make the industry more attractive to potential employees (Ndiango, Gabriel, & Changalima, 2024). Another option is to raise awareness and eliminate prejudice, with schools playing an important role in this. For instance, schools can incorporate logistics-related projects into subjects such as mathematics or geography, and organise field excursions to high-tech facilities, such as automated warehouses or air freight hubs, to inspire students (McKinnon, Flöthmann, Hoberg & Busch, 2017).

Pursuing this idea, the Austrian Federal Ministry for Climate Protection, Environment, Energy, Mobility, Innovation and Technology has established the "Research and Education on Transport Logistics" (RETrans) competence centre in cooperation with relevant stakeholders from industry, research and the public sector (RETrans, 2026). The focus is on a web platform offering quality-assured, freely accessible information and teaching materials on the subject of transport logistics. This comprehensive offering has been available since 2016 and proofed to be very successfully. However, significant changes in the logistics industry require an update to the platform to ensure its continued relevance. Moreover, several areas for improvement have been identified that are crucial to the platform's future success.

The remainder of the paper is structured as follows: The second section outlines the objectives and the methods that were employed in this research. The third section presents the results of the evaluation of the web platform RETrans, while the fourth section of this paper gives recommendations for the redesign of the platform.

2. Objectives and methods

The evaluation pursues two main objectives. Firstly, it aims to gain insights into how to improve the quality and user base of the platform. Secondly, it seeks to identify approaches to ensure the platform's continued relevance.

The evaluation follows a mixed methods approach, integrating both quantitative and qualitative research methods within a single study (McLeod, 2024). It comprises an online survey of school students, a workshop with didactics and e-learning experts, workshops with teachers and logisticians, as well as a focus group with university students. The online survey followed the "Toolbox for Continuous Website Evaluation and Quality Assurance" (Thielsch & Salaschek, 2017), which allows for a reliable assessment of user experience. The workshop involving didactics and e-learning experts, representing the fields of higher education didactics, e-learning, and digitalization, utilized a structured framework designed to assess the platform across content-related, functional, design-oriented, and didactic aspects. The workshops with teachers and logistics experts were designed to reflect upon evaluation results from the survey and expand it through practice-oriented feedback. The workshop with teachers featured representatives from various school types and the workshop with logistics experts included representatives from various sectors, like rail logistics, retail logistics, supply chain management, and consulting. The focus group involved 12 logistics students who worked on three central questions: how they became aware of logistics, the reasons why they chose a logistics degree programme, and potential measures to increase interest in logistics.

3. Results

3.1. Survey among school students

A survey of 129 school students with various educational backgrounds focused on seven constructs: first impression, overall impression, perception of content, usability, visual aesthetics, willingness to revisit, and willingness to recommend the site (Thielsch & Salaschek, 2017). The school students emphasised the high quality and practical value of the transport and logistics information, as well as its accessibility and clarity. However, the "liking" factor — whether they found the content enjoyable — received comparatively lower scores, indicating a need for more engaging presentation formats. Furthermore, the platform received an average rating in terms of usability and aesthetics. These results suggest that some optimisation is required to meet the high expectations of "digital native" users. Despite this critique, the initial and overall impressions were favourable. The school students expressed a clear willingness to revisit the platform and recommend it to others.

Through open-ended questions, the participants provided detailed feedback on the platform's practical applicability. The school students appreciated the simple and information-rich structure, the clear overview of topics, and the variety of media, including videos, games, and exercises. Critical feedback focused on compatibility with mobile devices, specific colour choice, and difficulties in navigating to certain teaching materials. There has been a strong interest expressed in further content on the subjects of sustainability and ecological transformation, digitalisation and technological trends, the international dimension of logistics, and global supply chain management. There has also been interest in innovations and future career opportunities in the logistics sector.

In summary, the evaluation confirms that, although RETrans provides high-quality, very trustworthy educational content, future development requires the interface to be visually and functionally modernised. To enhance its appeal to young people, the platform should adopt a mobile-first approach and integrate more interactive, self-organised learning tools reflecting current megatrends in logistics, such as digitalisation and sustainability.

3.2. Workshop with experts in didactics and e-learning

In parallel with the school student survey, a structured expert evaluation was conducted by higher education specialists in didactics and e-learning to assess the RETrans platform across five core dimensions: transparency, content, didactics, usability, and aesthetics.

The experts noted that the landing page does not clearly define its target audience, and that the platform does not systematically differentiate its content according to educational levels. A key issue raised was the lack of advanced filtering options, i.e., users cannot filter materials by educational level or specific didactic methods. This limitation somewhat restricts the platform's usefulness for educators. The subpages of the platform offer a variety of logistic-related topics, including sustainability, digitalisation, and social challenges. However, these are often rather hidden due to the site's specific architecture. The experts recommended giving these industry-relevant megatrends greater prominence. Moreover, it has been noted that the majority of materials currently lack explicit learning objectives, assessment criteria and grading keys. This hinders their seamless integration into official school curricula. Experts have also identified the need of more resources to support modern instructional concepts, such as the "flipped classroom". It was recommended to add more interactive digital tools, like online quizzes, to encourage self-organized learning. In regard to the user interface, the main page was found to lack a search function, while the navigation between subpages was also described as not very intuitive.

The expert evaluation concludes that the RETrans platform offers an excellent repository of high-quality information but requires some adaption to ensure outstanding performance. Key recommendations include implementing a target-group-specific design, enhancing didactic metadata, and integrating interactive digital learning technologies to better support contemporary educational standards.

3.3. Workshops with teachers and logistics experts

Two workshops were conducted with teachers and logistics industry professionals to gather practice-oriented insights.

The workshop, which involved teachers from various secondary school types, aimed to identify how to effectively integrate logistics topics into the classroom. They emphasised that practical examples from the learners' own lives, such as a supply chain of an everyday product, are the most effective way to inspire students. The key thematic priorities identified were internationality, sustainability, and career opportunities, with a particular focus on attracting more young women to the field. There is a strong preference for compact, modular materials rather than overwhelming, comprehensive learning packages. In addition, materials designed for self-study were found to be more useful in modern classrooms than purely teacher-led instructions. Educators suggest game-based learning (e.g., business simulations, role-plays, and serious games) that allow students to experience real-world logistics problems.

Experts from the logistics sector offered recommendations on how to further strengthen the platform's impact. It was suggested that logistics should be highlighted as a society-relevant industry. Megatrends such as digitalisation, decarbonisation and global supply chain resilience should be covered in order to demonstrate the sector's innovation potential. Experts highlighted that a successful platform must create measurable value for all users. Therefore, students should gain relevant competences, teachers should receive high-quality, curriculum-aligned materials, and companies should benefit from an improved image of logistics. In terms of the competencies and skills required by the industry, it has been stated that general competencies, such as teamwork, communication and customer orientation, are gaining more significance than purely subject-specific logistics skills.

In conclusion, these workshops have emphasised the necessity to concentrate on interdisciplinary soft skills, interactive and modular teaching formats, and the industry's role in solving global challenges such as ensuring sustainability.

3.4. Focus group with logistics students

In order to meet the needs of young people when redesigning the RETrans platform, a focus group with twelve logistics students was conducted.

The students described the various ways in which they had first encountered the logistics sector. Most commonly they became aware through school activities, teachers, or specializations in vocational schools. Although traditional brochures were mentioned, it was concluded that modern digital channels were becoming an increasingly relevant tool for raising awareness.

The decision to pursue a degree or career in logistics was driven by a set of motive bundles. A key motivator is job security, underpinned by the understanding that logistics is a universal and essential field, even during periods of economic or political turbulence. Students are also attracted by the diversity of tasks and the wide range of career paths available. The potential to earn a high income and to progress into leadership roles are also key factors in the decision to pursue a career in logistics.

The participants proposed several innovative measures to improve the industry's image and attract young people. They recommended incorporating logistics into school curricula at an earlier stage, potentially as a compulsory element of business-related subjects, to foster an understanding of its importance to society. The focus group results also highlight a clear need for the industry to modernise its communication methods. Furthermore, students emphasised the importance of making logistics more tangible by providing practical experience and using gamification techniques, such as escape games, serious games, and virtual learning platforms.

4. Recommendations

The comprehensive evaluation of the RETrans platform involved various stakeholders and highlighted the platform's strengths, in particular the excellent quality and trustworthiness of the content offered. It also revealed some opportunities for structural and visual modernisation. Considering the presented findings, six specific design principles have been formulated and will be incorporated into the redesign of the existing platform:

(1) Focus on the "twin transition": The platform is required to evolve beyond conventional transport logistics, emphasising the ecological and digital transformation of the logistics sector. This includes new content modules on decarbonisation and digitalisation to attract those interested in these megatrends.

(2) Target-group-specific navigation structure: The platform should be organised into three distinctive sections to serve the needs of various target groups: "Learn" (educational materials), "Explore" (up-to-date information on latest trends and innovations), and "Make a difference" (career paths and role models).

(3) Modern user experience: To meet the expectations of "digital natives", a visual und functional overhaul of the user interface is required. This includes a mobile-first design, a central search function and professional filtering systems to ensure ease of use for both teachers and students.

(4) Didactic professionalization and modularity: Teaching materials have to include learning objectives, curriculum alignment, and other relevant metadata. Materials should be provided in the form of modular components to support various teaching and learning concepts.

(5) Career orientation: To address the industry's perceived image, the platform should feature a wide variety of job profiles and authentic role models. Showing the diverse opportunities available in the occupational field, rather than providing abstract information, will encourage young people to find out more about logistics.

(6) Maintaining the unique selling proposition: The redesigned platform must remain a freely accessible, scientifically grounded information hub. By collaborating with well-established institutions while maintaining a strict policy of impartiality, the platform upholds its reputation as a reliable source of information in Austria.

To summarise, the primary objectives of the "RETrans – Logistics4Future" project are centred on modernising the existing knowledge platform to attract a new generation of professionals and on addressing the significant changes within the industry. The start of the redesigned platform is scheduled for Spring 2026. The outlined approach to evaluating and improving the platform may inspire similar initiatives in other fields, not just logistics.

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INNOVATIVE TECH CHALLENGES AS CATALYSTS OF STUDENT CREATIVITY: CROSS-NATIONAL EVIDENCE FROM THE ERASMUS+ SMART SOLUTIONS PROJECT

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Abstract

Purpose: This paper presents findings from the *Innovative Tech Challenges* (IO2) of the Erasmus+ *Smart Solutions* project (2024–2026), which aims to enhance digital literacy and creativity through scenario-based learning activities in secondary education across Europe. *Method:* Seventy digital challenges integrating problem-based learning, design thinking, and visual-based learning were co-created by partners from Ireland, Turkey, Latvia, Portugal, Italy, Romania, and Poland. The 2025 piloting phase involved 312 students and 68 teachers who completed selected tasks and provided feedback through post-piloting questionnaires and follow-up interviews. *Results:* Self-reported data indicate significant perceived improvement in digital creativity and problem-solving competences, particularly within DigComp areas 4 and 5. Students emphasized increased motivation, collaboration, and confidence in using digital tools, while teachers noted improved facilitation skills and readiness to apply open-ended, technology-supported methods. *Conclusions:* The results suggest that narrative-driven, challenge-based learning effectively promotes creativity and transversal competences in diverse classrooms. The paper outlines key pedagogical insights and practical guidelines for integrating such digital challenges into curricula and sustaining innovation through European cooperation.

Keywords: *Digital competences, creativity, problem-based learning, design thinking, Erasmus+, secondary education.*

1. Introduction

The digital transformation of education has increased demands for pedagogical approaches that move beyond functional ICT skills toward creativity, problem-solving, ethical awareness, and learner agency (OECD, 2019; Voogt et al., 2015). This shift is reflected in policy frameworks emphasising transversal and transformative competences for participation in digitally mediated societies. In Europe, DigCompEdu identifies creativity, digital content creation, and reflective practice as core dimensions of effective digital teaching (Redecker, 2017), while the OECD Learning Compass 2030 places creativity and responsibility at the core of future-oriented education (OECD, 2019).

Despite this policy consensus, translating competence frameworks into classroom-ready practice remains challenging. Digital learning often remains tool-oriented, offering limited opportunities for open-ended, creative, and socially meaningful engagement (Tondeur et al., 2017). This gap underscores the need for structured yet flexible instructional designs applicable across diverse contexts.

The Erasmus+ *Smart Solutions* project (2024–2026) addresses this need through *Innovative Tech Challenges*—narrative-driven, scenario-based learning activities designed to foster creativity and digital competence. By embedding digital tool use within authentic problem situations and creative production tasks, the challenges aim to operationalise competence-based goals in pedagogically coherent ways.

Although project-based learning, problem-based learning, digital storytelling, and design thinking are well documented as effective for developing digital competence and engagement (Hmelo-Silver, 2004; Krajcik & Blumenfeld, 2006; Robin, 2016), integrated scenario-based resources remain scarce. Moreover, alignment between competence frameworks and classroom tasks is often weak (Redecker & Punie, 2017), and creativity, ethics, sustainability, and career readiness are still frequently treated as separate priorities despite their interdependence in contemporary digital societies (OECD, 2019; UNESCO, 2018).

The present study positions the *Innovative Tech Challenges* as a response to these gaps by examining their pedagogical design and perceived impact in authentic school settings. The purpose of this paper is to examine the *Innovative Tech Challenges* developed within the Erasmus+ *Smart Solutions* project (2024–2026) as a structured, scenario-based pedagogical response to the gap between competence-oriented

policy frameworks and classroom practice. The study explores how narrative-driven digital challenges, grounded in active learning pedagogies, function as catalysts for student creativity and digital competence development across diverse European secondary education contexts. To achieve this aim, the study addresses the following research questions:

1. How do the scenario-based *Innovative Tech Challenges* integrate established active learning methodologies such as project-based learning, problem-based learning, design thinking, and digital storytelling?
2. What pedagogical functions do these scenario-based challenges serve in fostering student creativity and digital competence?
3. How do students and teachers perceive the impact of the *Innovative Tech Challenges* on learning processes, engagement, and teaching practice?
4. How do the scenario-based challenges complement existing international digital competence frameworks and policy initiatives?

2. Conceptual and theoretical framework

The conceptual framework of this study draws on contemporary theories of creativity, digital competence, and active learning. It integrates sociocultural perspectives on creativity with competence-oriented models of digital education and pedagogical approaches that emphasise authentic, collaborative, and design-oriented learning, providing the analytical lens for examining the *Innovative Tech Challenges.*

Creativity is conceptualised not as an individual disposition, but as a situated and socially mediated competence emerging through problem-solving, design, and meaning-making activities supported by cultural tools, including digital technologies (Glăveanu, 2014; Sawyer, 2012). This perspective aligns with contemporary digital competence frameworks that position creativity and digital content creation as core dimensions of participation in digital societies. DigComp identifies creative digital production and responsible content use as central competence areas (Vuorikari et al., 2022), while DigCompEdu emphasises learning designs that enable learners to create, reflect, and engage critically with digital media (Redecker, 2017). Empirical research further indicates that creative digital tasks—such as multimedia production, storytelling, and prototyping—support deeper cognitive engagement, particularly when learners are positioned as designers or problem-solvers (Henriksen et al., 2016; Robin, 2016).

The *Innovative Tech Challenges* are grounded in a convergence of learner-centred pedagogies. Problem-based and project-based learning support authentic inquiry and transferable skills (Hmelo-Silver, 2004; Krajcik & Blumenfeld, 2006), while design thinking contributes an iterative, user-centred problem-solving process (Razzouk & Shute, 2012). Digital storytelling and visual-based learning support multimodal meaning-making (Kress, 2010; Robin, 2016), and collaborative learning frames knowledge construction as a social process (Dillenbourg, 1999). Rather than applying these approaches in isolation, the challenges combine them into cohesive, scenario-based designs, responding to calls for pedagogical hybridity in competence-oriented digital education (Henriksen et al., 2016; Voogt et al., 2015).

The study is situated within key international frameworks, including DigComp and DigCompEdu (Redecker, 2017; Vuorikari et al., 2022), the OECD Learning Compass 2030 (OECD, 2019), and the UNESCO ICT Competency Framework for Teachers (UNESCO, 2018). While these frameworks articulate *what* competences should be developed, they offer limited guidance on pedagogical enactment (Tondeur et al., 2017). The *Innovative Tech Challenges* address this gap by translating framework-level competences into scenario-based learning designs that specify roles, tasks, tools, and reflective elements, thereby mediating between policy and classroom practice.

3. The *Innovative Tech Challenges*: Design and structure

The *Innovative Tech Challenges* form the core pedagogical intervention of the Erasmus+ *Smart Solutions* project and are designed as flexible, modular, scenario-based learning activities that translate competence-oriented policy frameworks into classroom-ready practice in secondary education. Grounded in research calling for pedagogically robust yet feasible instructional models (Bell, 2010; Tondeur et al., 2017), the challenges are underpinned by three interconnected design principles: narrative framing, which situates learners in authentic roles and real-world problems to enhance engagement (Barab et al., 2010; Robin, 2016); creative digital production, through which learners construct knowledge by creating shareable digital artefacts such as stories, prototypes, or interactive designs, consistent with constructionist and design-oriented learning theories (Papert & Harel, 1991; Kafai & Peppler, 2011); and reflective closure, which supports metacognitive awareness and competence development via structured reflection, peer feedback, and self-assessment (Zimmerman, 2002).

The scenario collection comprises 70 digital challenges, organised into seven thematic scenario families, each targeting a distinct dimension of digital competence, creativity, and transversal skills:

1. *Digital equity envoys* – accessibility, inclusive design, digital rights, and advocacy.
2. *Sustainable tech solutions hub* – sustainability, climate awareness, and eco-innovation.
3. *Adaptive learning apps workshop* – design thinking, prototyping, and data literacy.
4. *Digital narratives lab* – interdisciplinary storytelling and multimodal literacy.
5. *Global tech diplomacy* – intercultural communication, civic literacy, and European cooperation.
6. *CareerTech navigator workshop* – employability, digital identity, and ethical workplace practice.
7. *EduPlay innovators* – game-based learning and edutainment design.

Rather than constituting a linear curriculum, the scenario families form a pedagogical ecosystem. Teachers can select, adapt, and combine challenges according to curricular goals, learner characteristics, and local contexts, supporting both scalability and contextualisation. This modular structure aligns with research advocating flexible, competence-oriented learning designs capable of addressing complex educational aims in digitally mediated environments (OECD, 2019; Voogt et al., 2015).

4. Methodology

The study employs a mixed-methods exploratory design suitable for examining innovative pedagogical interventions in authentic educational settings (Creswell & Plano Clark, 2018). Reflecting the developmental and practice-oriented nature of the Erasmus+ *Smart Solutions* project, the research focuses on participants' perceptions of learning processes, pedagogical value, and feasibility rather than on experimental measurement of learning outcomes. Quantitative and qualitative data were collected concurrently during the piloting phase and analysed complementarily.

Data were collected during the 2025 piloting of the *Innovative Tech Challenges* in secondary schools across seven European countries (Ireland, Turkey, Latvia, Portugal, Italy, Romania, and Poland). Participants included 312 students and 68 teachers from diverse subject areas. Schools were selected to reflect varied socio-educational contexts, with voluntary participation and ethical standards, including informed consent and anonymisation, fully observed.

Teachers implemented selected challenges within regular teaching practice, with flexibility to adapt scenarios to curricular goals and available time. Implementation typically involved collaborative work, digital artefact creation, and structured reflection. Teachers received initial guidance but retained autonomy to ensure contextual responsiveness, consistent with prior research (Tondeur et al., 2017).

Data sources included post-implementation student and teacher questionnaires and semi-structured teacher interviews. Questionnaire items were descriptive and reflective, aligned with competence-oriented evaluation approaches (Redecker, 2017). Quantitative data were analysed descriptively, while qualitative data were examined using thematic analysis combining deductive and inductive coding (Braun & Clarke, 2006). Triangulation enhanced credibility. The reliance on self-reported data, lack of a control group, and contextual variability limit causal claims and cross-context comparability; however, these constraints are typical of large-scale pedagogical innovation research and are addressed through transparent reporting and triangulation (Creswell & Plano Clark, 2018).

5. Results

Across participating countries, students reported perceived improvement in competences related to creative digital content creation, including the ability to design, adapt, and combine digital materials for specific purposes. Students frequently referred to producing multimedia artefacts such as digital stories, visual campaigns, prototypes, and interactive designs, describing these tasks as more open-ended and engaging than typical ICT activities. Students emphasised increased confidence in experimenting with digital tools and making design decisions independently or collaboratively. Rather than focusing on mastering specific software functions, students described learning in terms of using tools creatively to communicate ideas or solve problems. Teachers corroborated these perceptions, noting that the challenges supported creative problem-solving and encouraged students to move beyond procedural tool use. Teachers also reported that scenario-based tasks facilitated formative assessment of digital content creation processes, including ideation, iteration, and refinement, which they found difficult to observe in more traditional digital assignments.

Competences related to responsible and ethical digital participation were most evident in scenario families addressing digital equity, sustainability, global citizenship, and career readiness. Students reported increased awareness of issues such as accessibility, digital inclusion, ethical communication, and the social impact of technology use. Teachers noted that scenario-based discussions prompted students to articulate ethical considerations explicitly, particularly in relation to inclusive design, environmental responsibility,

and professional digital identity. These competences were described as emerging through dialogue, reflection, and decision-making rather than through direct instruction. While students did not always label these outcomes in technical DigComp terms, both student and teacher responses indicated engagement with values and behaviours associated with safe, responsible, and socially conscious technology use.

In addition to DigComp Areas 4 and 5, participants consistently reported development of transversal competences that supported digital competence acquisition. This included collaboration, communication, and problem-solving, particularly through group-based scenario work. Students described collaborative work as central to generating ideas, distributing tasks, and resolving challenges. Teachers observed that the scenario format supported learner autonomy and peer learning, with students assuming active roles in planning and decision-making.

Teachers perceived the *Innovative Tech Challenges* as pedagogically valuable and adaptable, enabling integration of DigComp-oriented learning outcomes into existing curricula. Many teachers reported a shift toward a facilitative role, focusing on guiding inquiry and reflection rather than providing step-by-step instruction. Implementation varied across contexts in terms of duration, subject focus, and digital tools used. Common challenges included limited instructional time and heterogeneous student digital skills; however, teachers generally reported that the modular design of the challenges allowed for contextual adaptation without compromising core learning objectives. Reflective components were identified as particularly important for supporting competence awareness, though teachers noted that these required deliberate scaffolding to be effective.

6. Discussion

This study examined the *Innovative Tech Challenges* as a scenario-based response to the gap between competence-oriented digital education frameworks and classroom practice, addressing the research questions through the lens of the DigComp framework, with particular attention to Area 4 (Digital content creation) and Area 5 (Safety and responsible use).

The findings indicate that the *Innovative Tech Challenges* integrate project-based learning, problem-based learning, design thinking, digital storytelling, and collaborative learning in a coherent and mutually reinforcing way. The scenario format functions as an integrative pedagogical structure, enabling these approaches to operate synergistically rather than in isolation, in line with research advocating pedagogical hybridity in digital education (Henriksen et al., 2016; Voogt et al., 2015). Results further suggest that the challenges effectively support competences associated with DigComp Area 4, particularly creative digital content creation. Students' engagement in designing and producing digital artefacts reflects a shift from procedural tool use toward purposeful, creative production, consistent with sociocultural and constructionist views of creativity that emphasise design, iteration, and learner agency (Glăveanu, 2014; Papert & Harel, 1991). Teachers also reported that the scenario-based format enhanced the visibility and assessability of creative processes. Competences related to DigComp Area 5 emerged primarily through contextualised reflection and discussion embedded in the scenarios. Activities addressing digital equity, sustainability, and professional digital identity encouraged students to consider ethical and social implications of technology use, supporting prior research indicating that responsible digital participation is best developed through authentic, dilemma-based contexts (OECD, 2019; UNESCO, 2018). Both students and teachers perceived the *Innovative Tech Challenges* as positively influencing engagement and learning, with students reporting increased motivation and collaboration and teachers noting a shift toward facilitative teaching practices and greater learner autonomy. These findings align with existing evidence on the potential of scenario-based and project-oriented learning to support pedagogical change in digital contexts (Tondeur et al., 2017).

Overall, the findings suggest that the *Innovative Tech Challenges* complement DigComp and related frameworks by operationalising abstract competence descriptors through concrete, classroom-ready scenarios. However, the reliance on self-reported data and the absence of performance-based measures limit claims about learning outcomes, indicating a need for future research using objective and longitudinal assessment designs.

7. Conclusions

This study demonstrates that the *Innovative Tech Challenges* constitute a viable and pedagogically robust approach to operationalising DigComp-oriented goals in secondary education. By integrating narrative framing, creative digital production, and structured reflection within scenario-based learning designs, the challenges support the development of digital content creation competences and foster responsible, ethical participation in digitally mediated contexts. The findings suggest that positioning learners as active designers and problem-solvers enhances engagement, creativity, and learner agency,

while simultaneously encouraging a shift in teachers' roles toward facilitation and formative assessment. Importantly, the *Innovative Tech Challenges* function as a practical bridge between abstract competence frameworks and everyday classroom practice, offering adaptable and scalable pedagogical models that can be implemented across diverse educational contexts. While further research is needed to examine long-term learning outcomes, the results indicate that scenario-based, competence-oriented pedagogies hold significant potential for advancing creative and responsible digital education in Europe.

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ON THE IMPACT OF SUBJECT OF STUDY, SELF-REGULATION LEARNING AND MATHEMATICS ANXIETY ON ACADEMIC DROPOUT

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Abstract

Early dropout is a common problem in many universities due to its financial and social impact on the students themselves. In recent years, studies on variables that affect dropout and predictive models of dropout have become increasingly popular. By understanding the relationship between these variables, it is possible to design intervention strategies that help reduce dropout. In this study, we analyse the relationship between the relationship between two subdimensions of a construct of risk of university drop-out, subdimensions of the related to self-regulation construct, mathematics anxiety and subject of study. In particular, we wonder whether students from degrees of the same knowledge area attain similar scores on the variables considered. Data are collected from a sample of more than 700 students from three different universities. The results indicate several intercorrelations between the variables considered. Last, the degrees of Medicine and Architecture seem to be the most successful on retaining students, despite being from different knowledge areas. Testimonials from programme coordinators were gathered from each of these two degrees separately to provide insights on the reasons for this. The testimonials coincided in the need of professional academic advising programmes to support the transition to university as well as for preventing student burnt-out.

Keywords: *Self-regulation, motivation, drop-out, student retention, mathematics anxiety.*

1. Introduction

University dropout in Spain is one of the main weaknesses of the Spanish University System, affecting between 20% and 33% of undergraduate students, particularly during the first two years. Rates are lower in face-to-face public universities (around 20%) and higher in distance-learning institutions (above 40%), with the Canary Islands and the Balearic Islands showing the highest percentages (CRUE, 2024). This phenomenon, which is multicausal in nature, responds to academic, socioeconomic, personal, psychological, and institutional factors, including low academic performance, insufficient preparation, financial difficulties, lack of motivation, stress, and the absence of proper guidance (Nicoletti, 2019). Degree choice, limited access to the student's preferred programme, and difficulties balancing studies with other responsibilities also play a role. Its consequences are significant: at an individual level, it generates feelings of failure and loss of resources; at an institutional level, it entails inefficiency and worsens key indicators; and at a societal level, it reduces the proportion of graduates, thereby affecting the country's competitiveness.

Currently, there are three main approaches to studying dropout risk: the psychosocial approach, the predictive approach, and the hybrid approach. Psychosocial approaches aim to study how a set of psychosocial variables interact in academic dropout. One example of this type of model is Kerby (2015), which attempts to improve upon earlier models by Tinto (1975) and Bean (1985).

These models are useful for understanding the causal relationships among the different factors that contribute to the decision to withdraw from university studies. However, using this model as a computational system to predict student dropout risk would require a major effort to collect error-free data from many different sources. Therefore, there is a need to develop a more easily implementable instrument that can help lecturers or programme directors prioritise resources without requiring massive amounts of

data or high financial investment. A promising solution is offered in the study by Llauró (2024), which conducted a systematic three-year longitudinal study through structured interviews with tutors involved in the tutorial action plan, aiming to identify indicators of university dropout. These indicators were later correlated with actual dropout data. Although the original Llauró's instrument categorises the items into five dimensions, only two are considered in this paper: (1) academic satisfaction and (2) motivation and student habits. The rationale of choosing these two dimensions stems from a factor analysis exploration and a confirmatory factor analysis of this tool which concluded that these two dimensions have high reliability (reliability measures shall be reported in the upcoming sections). From Llauró's work (2023, 2024), these two dimensions are predictors of student drop-out. Therefore, these variables can be used as measures of the risk of dropping out. Measuring this risk is required to develop and implement support interventions to reduce this risk.

The main objective of this work is analysing the relationship between the self-regulation strategies (Vermunt, 2005), a three-dimensional construct consisting of: (I) self-regulation of learning process and content, (II) external regulation and (III) lack of regulation and the aforementioned dimensions of drop-out risk.

On the other hand, in (Barrera-Romero et al, 2025), it was shown that the construct of Mathematics Anxiety was positively correlated with "Lack of Regulation". Quantifying the relationship of Mathematics Anxiety and the corresponding measures of risk of drop-out is essential for understanding the scale of the effect of mathematics anxiety, especially, in STEM subjects. Quantifying this effect may help faculty staff to advocate for the appropriate mathematics support to enable students to overcome mathematics anxiety.

Last, we aim to understand whether interventions should be addressed at a degree level or rather to a set of degrees of a specific subject, i.e. Health Sciences, Engineering, Sciences, Social Sciences. This would imply that subject-related degrees attain similar profiles on the risk of drop out.

2. Method

To address the objectives of this project, a sample of 729 first-year undergraduate students from three different universities was collected. This sample completed an online questionnaire that included: (1) a modified version of the Vermont's ILS (1995) from Raisanen (2020), we shall refer to this as ILSm, (2) the Anxiety Towards Mathematics Scale (ATMS-11) instrument (Sarfo et al., 2022), and (3) the following items from the risk of dropout model of Llauró et al. (2023), listed below.

Table 1. Risk of drop out instrument considered.

Item No.	Item	Dimension
1*	You identify yourself as a student that usually attains _____ marks.	Satisfaction
2	How convinced are you that you made the right choice regarding the degree you are going to study?	Satisfaction
3	Do you believe that the study plan matches your expectations?	Satisfaction
4*	So far, how many hours of study do you dedicate each day to keeping up with the subjects?	Motivation and student habits
5	I identify myself as a student who plans their work from the very first day.	Motivation and student habits
6	What level of daily motivation do you have for studying?	Motivation and student habits

*Items 1 and 4 were answered in a 1-5 likert scale with answers "very low, low, average, high, very high" for item 1, and "very few, a few, average, more than average, many". Remaining items were answered with a 1-5 Likert scale with 1 being none or nothing, to 5 meaning much or a lot.

To analyse the relationships between the variables, we will carry out a correlation analysis, using the Spearman correlation coefficient, more appropriate for data from Likert scales with lack of normality. To obtain data about the dimensions of the instrument from Table 1, a mean average was calculated from the set of items of each dimension.

Regarding the internal consistency the ω of McDonald (Dunn et al., 2014) was calculated for each subscale: $\omega = 0.61$ for Academic Satisfaction and $\omega = 0.768$ which are acceptable for scales of 3 items. Similarly, the Cronbach alpha coefficients were alpha = 0.579 and alpha = 0.764 for each dimension respectively.

3. Results

Table 2. Spearman correlation matrix.

	Self-regulation	External Regulation	Lack of Regulation	Mathematics Anxiety	Motivation and study habits
External Regulation	0.259***				
Lack of Regulation	0.104**	-0.021			
Mathematics Anxiety	-0.030	0.037	0.426***		
Motivation and study habits	0.364***	0.249***	-0.079*	0.003	
Academic Satisfaction	0.249***	0.271***	-0.376***	-0.241***	0.368***

*,**,*** indicate p-value less than 0.05, 0.01, and 0.001 respectively.

Table 3. Descriptive statistics of the dimensions of risk of drop out: S "Academic Satisfaction and M "Motivation and study habits".

Degree	mean (S)	median (S)	sd (S)	mean (M)	median (M)	sd (M)
Medicine	4,38	4,33	0,39	3,58	3,67	0,74
Architecture	4,01	4	0,49	3,6	3,67	0,69
Computing	3,89	4	0,7	3,12	3	1,04
Biomedical Engineering	3,86	4	0,47	2,98	3	0,68
Law	3,81	4	0,49	2,94	3	1,08
Engineering	3,81	3,67	0,6	3,13	3	0,8
Mathematics	3,79	4	0,69	2,69	2,67	0,99
Biotechnology	3,76	4	0,73	3,04	2,83	0,97
Primary Education	3,62	3,67	0,59	3,1	3	0,81
Videogames	3,6	3,67	0,71	2,25	1,67	0,86
Busines and Management	3,58	3,67	0,57	2,62	2,67	1,11

4. Discussion

The first result is that there is a statistically significant relationship between the three dimensions of ILSm: self-regulation, external regulation, and lack of regulation, and the two dimensions of the risk of drop out. While self-regulation and external regulation are positively correlated with the dimensions of the risk of drop out, lack of regulation correlates negatively, being the correlation with motivation and study habits particularly weak (rho = - 0.079). Last, Mathematics Anxiety has a significant negative correlation with academic satisfaction.

Secondly, from Table 3, it can be observed that students from the degree in Medicine obtain the highest scores on “Academic Satisfaction” and “Motivation and Student Habits”, followed by Architecture.

One could think that students from Architecture would behave in a very different manner as those from Medicine. To find out some insights on what the explanation for this could be, we asked the corresponding programme managers for their views on this matter.

Both managers reported that the degrees of Medicine and Architecture are more extensive programmes consisting of six and five years of duration and demand a high level of autonomy. In both degrees, bilingual and even trilingual teaching is promoted. Furthermore, all the students of these two programmes go through a thorough academic advising track with trained professionals that provide not

only academic support but also personal support and guidance. It was clear from their testimonials, that the academic advising is strongly supported institutionally as a strategy to enhance student retention.

Regarding the challenges faced in these degrees, emphasis was made on the risk of burnout of Medicine students and the transition from high school to university. As a result, the academic advising serves not only to support students, but also as a path to investigate the factors leading to burnout or to better adaptation skills.

These findings are in line with Tinto's drop out model (1975) or Bean's model (1985) which state that lack of adaptation skills and thus of academic integration is one of the causes of drop-out. At the same time, the perception of the institutional commitment contributes to student retention what could explain, at least partly the positive effects of the academic advising services, according to Kerby's model (2015) of student retention.

Last but not least, coming back to the main research question of whether the subject of study has a relationship with academic drop out, we can state that the subject indeed affects to both dimensions of risk of drop out at a degree level, rather than at a subject or knowledge area level, since degrees of different areas such as Architecture and Medicine behave in a similar fashion. Further research could be conducted via cluster analysis and classification techniques to categorise degrees into groups having similar scores on self-regulation and drop out risk for facilitating tailored support programmes considering the corresponding needs. Last, a similar analysis could be carried out a student level for the same purpose of providing tailored support to a range of students with similar scores on academic satisfaction, motivation and study habits as well as other scores on relevant variables.

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GENDER STEREOTYPES IN EDUCATION: HIDDEN MECHANISMS AND THEIR IMPACT ON ATTITUDES TOWARD STEM

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Abstract

Despite the growing number of initiatives promoting equality in education, entrenched gender stereotypes continue to influence students' educational choices. Girls in particular often internalize beliefs about their alleged lack of aptitude for science and technology, which undermines their self-confidence and limits their participation in STEM subjects (science, technology, engineering, mathematics). The aim of this project is to identify and analyze gender stereotypes operating within the school environment and to assess their impact on girls' self-assessed competencies, motivation, and educational decisions. The study also seeks to highlight effective teaching strategies and support tools that may help neutralize these stereotypes. A mixed-methods approach was employed. The quantitative component involved a survey of secondary school students, measuring self-perceived abilities in science, attitudes toward gender roles, and declared educational choices. The qualitative component included focus group interviews with female students and teachers, exploring experiences related to gender equality and academic support. The data were analyzed using statistical and thematic methods. The findings indicate that gender stereotypes continue to significantly affect how girls perceive their scientific abilities. Protective factors include exposure to female role models and educational environments that promote equality and collaboration. The results may serve as a foundation for developing pedagogical recommendations and support programs aimed at empowering girls in STEM, as well as for informing educational policies focused on reducing gender disparities.

Keywords: *Gender stereotypes, STEM, educational equality.*

1. Introduction

Despite sustained international efforts to promote gender equality in education, significant gender disparities persist in science, technology, engineering, and mathematics (STEM), particularly in mathematics-intensive and technical fields such as physics, engineering, and information technology. These disparities remain notable despite the convergence of overall academic achievement between girls and boys across many countries (Else-Quest et al., 2013; Mann et al., 2015), suggesting that differences in ability alone cannot explain gendered participation patterns. Instead, socio-cultural and institutional factors appear to shape students' motivations, attitudes, and educational aspirations.

Secondary education represents a critical developmental period during which students form academic self-concepts and make decisions influencing future career trajectories. Research shows that gender gaps in STEM attitudes and intentions widen during this stage even when achievement differences are controlled (Legewie & DiPrete, 2014; Salmela-Aro et al., 2020). These differences are linked less to performance decline than to gendered shifts in self-efficacy, interest, and perceived belonging within STEM domains.

Gender stereotypes play a central role in shaping these trajectories. Stereotypical beliefs about who is "naturally suited" for STEM are embedded not only in explicit attitudes but also in everyday practices, teacher expectations, peer interactions, and broader cultural narratives (Makarova et al., 2019; Raabe et al., 2019). As a result, girls may internalize lower confidence and weaker identification with STEM despite comparable performance levels. Cross-national research further reveals the "gender-equality paradox," whereby stereotypes associating mathematics with men can be stronger in economically developed and gender-egalitarian societies, highlighting the role of cultural mechanisms in shaping educational choices (Breda et al., 2020).

The present paper synthesizes empirical research on gender stereotypes in education to examine hidden mechanisms of stereotype transmission and their impact on STEM-related attitudes, including self-efficacy, interest, and career aspirations.

2. Theoretical framework

Gender stereotypes in STEM can be conceptualized as multidimensional constructs encompassing beliefs about ability, identity, and occupational suitability. Research identifies three primary dimensions: ability-based stereotypes, career-oriented stereotypes, and subject-specific stereotypes (Makarova et al., 2019; Tellhed et al., 2023). Ability stereotypes portray boys as naturally more suited to mathematics and technical reasoning, while career stereotypes frame STEM professions as masculine domains. Subject-specific stereotypes further create hierarchies within STEM, with mathematics and physics most strongly associated with masculinity (Raabe et al., 2019; Breda et al., 2020).

These stereotypes function as socially shared belief systems embedded in institutional practices. From a sociological perspective, they act as symbolic boundaries signaling who belongs in particular academic fields (Legewie & DiPrete, 2014), while from a social-cognitive perspective they shape students' interpretations of feedback and social comparison, influencing motivation and self-concept (Chan, 2022). Notably, girls often perceive STEM as a uniformly masculine domain, whereas boys differentiate between subjects, which has implications for intervention design.

Peer dynamics represent a key mechanism of stereotype reproduction, as students align interests with perceived gender norms to maintain social acceptance (Raabe et al., 2019). The presence of female peers interested in STEM can function as a protective factor by validating non-stereotypical identities, whereas male-dominated environments may reinforce perceptions of non-belonging. Teachers also play a dual role as both transmitters and potential disruptors of stereotypes. Teacher expectations and implicit biases influence feedback and instructional practices (Makarova & Herzog, 2015), while exposure to female teachers can increase girls' engagement with advanced STEM pathways (Lim & Meer, 2017), though effects vary depending on context (Riegle-Crumb et al., 2017).

Family influences further shape gendered trajectories through differential encouragement and parental beliefs about ability and career suitability (Fernández García et al., 2019; Blažev et al., 2021). Together, these multi-level mechanisms contribute to cumulative socialization processes that sustain gendered participation patterns. Cross-national findings indicate that stronger gender stereotypes may coexist with higher levels of structural equality, suggesting that cultural narratives and identity processes play a crucial role in maintaining gender segregation in STEM (Breda et al., 2020).

3. Research objectives

The aim of the empirical part of the study was to determine how perceived and internalized gender stereotypes influence attitudes toward STEM among female students at educational stages associated with the formation of academic decisions. Particular attention was devoted to three interrelated constructs: (1) STEM self-efficacy, (2) sense of belonging within the STEM domain, and (3) declared educational intentions. An additional objective was to identify hidden mechanisms of stereotype transmission through the analysis of participants' experiences as well as their recommendations regarding institutional actions aimed at reducing stereotyping.

4. Methodology

The study employed a mixed-methods design, combining a quantitative component (an online survey) with a qualitative analysis of open-ended responses.

The study sample consisted of N = 79 participants. Participants' ages ranged from 16 to 20 years, with a clear concentration between 17 and 19 years of age. The educational profile of participants was diverse; however, the medical field predominated (58.2%), indicating that a substantial portion of the sample was situated within STEM-related disciplines.

A set of five-point Likert scales was employed, including:

- STEM Intentions (SI),
- Internalized Stereotypes / Belonging Threat (IST),
- Female Role Model Exposure (FRM),
- STEM Self-Efficacy (SSE),
- Equity-Oriented Classroom Climate (ECC),
- Perceived Gender Stereotypes (PGS).

Additionally, focus group interviews were conducted with female students and teachers, aimed at exploring experiences related to gender equality and academic support. Quantitative data were analyzed at the level of response distributions and interpretative trends between psychological constructs. Qualitative data were subjected to thematic analysis to identify dominant narrative patterns.

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5. Results

Response distributions in the STEM Intentions (SI) module indicate substantial heterogeneity in participants' declarations: while some respondents are considering or planning STEM-related educational pathways, a parallel group remains uncertain or distanced from such plans. These findings are consistent with the sample profile (strong representation of medical and science-related fields) as well as the reported level of engagement with STEM subjects (approximately 73% indicating "yes" or "partially").

In the STEM Self-Efficacy (SSE) module, responses more frequently reflected moderately high confidence in one's abilities to perform STEM-related tasks ("rather agree" and "strongly agree"). At the same time, a significant proportion of neutral responses emerged in items referring to coping with novel, demanding, or evaluative situations. This pattern suggests a profile in which general competence confidence coexists with sensitivity to evaluative contexts and social comparison processes, consistent with literature on belonging threat mechanisms and the stereotypical coding of STEM domains.

In the Perceived Gender Stereotypes in STEM (PGS) module, responses predominantly indicate that participants recognize the presence of gender stereotypes within educational and broader social environments, including media representations. The Internalized Stereotypes/Belonging Threat (IST) module suggests that a subset of respondents experiences elements of belonging threat (e.g., doubts about "fitting" into STEM domains). At the same time, several items elicited a higher proportion of neutral responses, which may reflect heterogeneity of experiences, including differences across schools or universities, group compositions, and varying exposure to stereotypical comments or discriminatory practices.

In the Female Role Model Exposure (FRM) module, there is simultaneous evidence of (1) high declared awareness and recognition of women present in STEM fields and (2) signals suggesting that their visibility within educational and symbolic spaces is perceived as insufficient. Quantitative findings are consistent with open-ended responses, in which contact with female teachers/lecturers or well-known figures was described as a factor enhancing motivation, normalizing a sense of belonging, and reducing feelings of being "out of place."

Response distributions in the Equity-Oriented Classroom Climate (ECC) module suggest that a substantial proportion of participants perceive their educational environment as relatively supportive of equality (at least in certain aspects). However, responses are not homogeneous, and some items reveal clear signals of tension related to differences in gender-based treatment. This pattern is directly reflected in the qualitative materials (see Section 5.5).

The thematic analysis of open-ended responses identified five dominant areas:

- Unequal expectations and distribution of opportunities in the classroom (teacher expectation bias): respondents described, among others, more frequent selection of boys for challenging tasks, answering questions, and participation in competitions, as well as the relative downplaying of girls' achievements; references were also made to a form of "leniency" toward boys combined with attributing greater "talent" to them.
- Stereotypical comments and microaggressions as mechanisms of everyday norm reproduction: participants reported situations in which girls were told they were "weaker in mathematics," that technical education paths were "for boys," or experienced comments from peers or teachers that questioned their competence.
- Social pressure, fear of evaluation, and mechanisms of continuous comparison: responses concerning girls' withdrawal from STEM frequently highlighted low self-confidence, fear of making mistakes, social pressure, and concerns about being the only woman in a group, which was associated with discomfort and heightened scrutiny.
- Role models as a protective but conditional factor: contact with women in STEM was often described as strengthening motivation and agency ("it showed me that I also have a chance"); however, some responses suggested that the mere presence of women is insufficient if the environment remains a "chilly climate" or if teachers do not actively support engagement.
- Institutional recommendations: from symbolic representation to procedural change: proposed actions included consistent responses to stereotypical comments, clear anti-discrimination procedures, anonymous assessment practices, changes in language and teaching materials, increased visibility of women in STEM (media, schools, lectures), and meetings with women working in STEM professions; many responses emphasized the importance of practicing equal treatment rather than relying solely on formal declarations.

6. Discussion

Empirical findings support the theoretical framework presented in Section 2, indicating the multi-level operation of gender stereotypes within school environments. First, quantitative data suggest the coexistence of moderately high STEM self-efficacy alongside a simultaneous recognition of stereotypes in the surrounding environment. This profile is consistent with literature showing that the key domain of inequality may not lie solely in competence itself, but rather in how competence is interpreted within the context of gender norms, social comparison, and signals of belonging.

Second, qualitative data reveal "hidden" mechanisms (hidden curriculum) manifested through routine instructional practices (e.g., who is selected for tasks, how teacher attention is distributed, to whom "talent" is attributed), as well as peer-driven mechanisms reinforcing gender norms. Narratives describing social pressure, fear of evaluation, and being the "only girl" in a group align with the concept of belonging threat, which—consistent with the proposed framework—may weaken STEM intentions and persistence regardless of actual performance levels.

Third, the convergence of FRM results and open-ended responses indicates that exposure to female role models functions as a protective factor; however, its effectiveness depends on how it is embedded within the institutional environment. While role models may help "normalize" a sense of belonging, they cannot substitute for formal procedures addressing stereotyping nor compensate for the systematic lowering of expectations toward girls.

7. Conclusions

The collected data indicate that gender stereotypes remain a significant component of STEM-related educational experiences, operating primarily through psychosocial mechanisms such as sense of belonging, fear of evaluation, and the interpretation of difficulties as evidence of a lack of aptitude. The findings suggest that the key domain of inequality lies not solely in differences in competence, but in how competence is interpreted within the context of social norms, signals of belonging, and everyday educational practices. At the same time, protective factors were identified, particularly exposure to female role models and educational environments that support equality and collaboration, which may strengthen girls' motivation and identification with STEM.

Participants' recommendations highlight the need to combine symbolic actions, such as increasing the visibility of women in STEM and using inclusive language and teaching materials, with procedural measures including consistent responses to stereotyping, the implementation of clear anti-discrimination standards, and the equitable distribution of tasks and developmental opportunities. This suggests that effective interventions require a systemic approach aimed at disrupting stereotype transmission mechanisms at the level of classroom interactions and institutional structures, rather than solely strengthening individual motivation among female students.

From an educational policy perspective, the study findings point to the need to move beyond strategies focused primarily on increasing access to STEM toward approaches that address the psychosocial determinants of girls' educational choices. This includes developing teachers' competencies in stereotype-sensitive pedagogy, implementing equity-oriented standards in assessment and classroom organization, and establishing long-term programs that enhance the visibility of women in STEM as a means of normalizing a sense of belonging.

The integration of quantitative and qualitative data in this study demonstrates that gender stereotypes in STEM function primarily as a system of hidden social signals shaping individuals' interpretations of their own competence and educational decisions. Consequently, reducing gender inequalities in STEM requires simultaneous interventions at the level of individual beliefs, social dynamics, and structural educational conditions. This represents a key direction for future research as well as for the development of pedagogical practices and educational policies aimed at strengthening girls' participation in STEM.

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TEACHERS' PERCEPTIONS OF LEARNER SUPPORT IN SOUTH AFRICAN RURAL SECONDARY EDUCATION

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Abstract

This study investigates how teachers in South African rural secondary schools understand and enact learner support in contexts characterised by poverty, geographic isolation, and limited services, with a focus on the psychosocial and academic dimensions, and on the potential of inclusive and decolonial practices to improve outcomes. Two quintile 1–2 public secondary schools in one district were conveniently selected for their high socio-economic disadvantage and documented learner vulnerability, and six teachers were purposively sampled to represent varied subjects, experience, and roles within learner support structures. Using a qualitative participatory action research design grounded in a constructivist paradigm and informed by Community of Practice theory, the study positioned teachers as co-researchers. Data were generated through collaborative group discussions and reflective diaries, capturing teachers' everyday practices and emerging understandings of decolonial psychosocial care, and were analysed thematically with collaborative validation and verbatim quotations. Teachers reported pervasive barriers to effective learner support, including overcrowded classes, limited access to specialist psychosocial services, food insecurity, and the emotional strain of working in high-poverty, high-trauma environments. Concurrently, they identified key local assets, such as strong family–school relationships, learner peer solidarity, and supportive faith and community networks that they mobilised as community-linked support. Teachers described using a range of inclusive pedagogical strategies, particularly differentiated instruction and cooperative learning, and associated decolonial psychosocial support with valuing learners' cultural identities, using home languages, and integrating indigenous and communal practices of care. The study concludes that teachers' contextually grounded practices, decolonial orientations, and community partnerships provide a vital foundation for stronger learner support, but that systemic constraints limit their impact. It recommends that policy commitments to inclusion and decoloniality be supported by targeted investments in teacher professional development, strengthened school-based support teams, formalised partnerships with local services and communities, and improved resourcing for rural schools. These measures are essential to move towards a more equitable and responsive system of learner support in South African rural secondary education.

Keywords: *Inclusive pedagogy, psychosocial support, learner support, teacher perceptions, South Africa.*

1. Introduction

Rural education in South Africa is marked by intersecting structural inequalities that shape how learner support is conceptualised and enacted. Legacies of apartheid spatial planning, persistent poverty, and under-resourcing have produced rural schooling contexts characterised by multigrade classes, limited specialist services, and high levels of psychosocial need (du Plessis & Mestry, 2019). At the same time, national policy frameworks such as Education White Paper 6 and the Care and Support for Teaching and Learning (CSTL) programme mandate inclusive, holistic support for all learners (DoE, 2001; DBE, 2025).

Despite these commitments, most empirical work on learner support and inclusive education in South Africa has focused on urban or peri-urban contexts (Makoelle, 2022), with comparatively little attention to how rural teachers understand and implement psychosocial and academic support in everyday practice. Moreover, decolonial scholarship argues that support systems often reproduce Eurocentric norms and disregard local knowledges, languages, and community-based forms of care (Boughey & McKenna, 2021; Omodan, 2024). This study addresses these gaps by examining teachers' perceptions of learner support in rural secondary schools, foregrounding psychosocial dimensions, and exploring how inclusive and decolonial practices are negotiated under severely constrained conditions.

The study focuses specifically on rural, quintile 1–2 secondary schools, which remain under-represented in the learner support literature. It employs participatory action research (PAR) and Community of Practice (CoP) as a combined lens, positioning teachers as co-researchers rather than subjects of investigation. The study also explicitly examines teachers' emerging understandings of a decolonial approach to psychosocial support, an area in which empirical studies remain scarce (Sayed & Ahmed, 2023).

2. Objectives

The study was guided by the following objectives:

- To explore how teachers in rural secondary schools conceptualise learner support, with particular attention to psychosocial and academic dimensions.
- To examine how teachers perceive a decolonial approach to psychosocial support in their schools.
- To generate collaboratively grounded recommendations for strengthening learner support in rural secondary education.

3. Literature review

3.1. Learner support, inclusion and rurality

Learner support is understood as the set of academic, psychosocial, and material interventions that enable learners to participate and succeed in schooling (Pillay et al., 2023). Inclusive education scholarship has shifted the focus from "fixing" individual learners to transforming school cultures, policies, and practices to accommodate diversity (Ainscow, 2020; Walton, 2018). In South Africa, however, implementation of inclusive learner support remains uneven, particularly in rural and under-resourced schools where large classes, negative attitudes, and limited specialist services persist (Donohue & Bornman, 2014; Engelbrecht & Savolainen, 2018).

Rural schooling is often framed through deficit narratives that emphasise failure and scarcity, yet research also highlights significant local assets, including strong social cohesion, local knowledge systems, and community-school partnerships (Nyathi, 2025; Ebersöhn, 2019). Place-conscious and decolonial perspectives argue that rural education must be understood on its own terms, rather than judged against urban norms (Corbett, 2015; Moletsane, 2012).

3.2. Psychosocial support and decolonial perspectives

High levels of poverty, violence, and family disruption contribute to elevated psychosocial risk among South African learners (Cluver et al., 2015; Sherr et al., 2014). Policy frameworks such as Care and Support for Teaching and Learning CSTL position schools as hubs of psychosocial support, but in practice, rural schools face acute shortages of school psychologists, social workers, and school-based support teams (DBE, 2018; Pillay et al., 2023). Teachers are often de facto frontline providers but feel under-prepared and overburdened (Mampane, 2020).

Decolonial scholars argue that psychosocial support must move beyond imported, individualised models and engage with indigenous knowledge systems, collective forms of care, and local idioms of distress (Seedat et al., 2009; Zembylas & Chubbuck, 2020). They caution that ignoring learners' contexts constitutes a denial of reality, undermining motivation and well-being (Boughey & McKenna, 2021). Empirical work on how such decolonial approaches are understood and enacted by rural teachers remains limited (Sayed & Ahmed, 2023), underscoring the need for studies like the present one.

4. Community of practice theory

Community of Practice (CoP) theory conceptualises learning as a social process that occurs through participation in shared practices, rather than as the transmission of information to isolated individuals (Lave & Wenger, 1991; Wenger, 1998). A CoP is characterised by a shared domain of interest, a community that interacts regularly, and a repertoire of shared practices and resources (Marongwe & Chisango, 2022). In this study, CoP provides a lens for understanding how rural teachers collectively negotiate the meanings of "learner support" and how they develop, share, and refine practices of psychosocial and academic support under challenging conditions. Viewing teachers as members of an evolving CoP aligns with the participatory action research design and supports the goal of co-creating contextually grounded strategies rather than imposing external solutions.

5. Methods and design

A qualitative Participatory Action Research (PAR) design, rooted in a constructivist paradigm, was used. PAR emphasises collaboration between researchers and co-researchers to critically examine and transform a shared concern (Reason & Bradbury, 2008; Burns, 2007). The constructivist stance assumes that knowledge is co-constructed through social interaction and that multiple realities exist (Creswell & Poth, 2016). This made PAR appropriate for exploring teachers' lived experiences and meanings of learner support, while also opening possibilities for change. Two rural, quintile 1–2 public secondary schools were conveniently selected from a single education district. Selection criteria included high levels of socio-economic disadvantage, geographic isolation from urban centres, and evidence from district reports of high learner vulnerability (e.g., orphanhood, household food insecurity). Within these schools, six teachers were purposively sampled to ensure diversity in subject specialisation (e.g., languages, sciences, life orientation), years of teaching experience, and Involvement in learner support structures (school-based support teams, class teachers, life skills teachers). These teachers were invited to act as co-researchers in line with the PAR ethos.

Two main methods were used to generate data: collaborative group discussions and reflective diaries. For collaborative group discussions, three rounds (approximately 90 minutes each) were conducted with the six co-researchers over a two-month period. Discussion prompts focused on understanding learner support, everyday practices, challenges, and strengths, and perceptions of inclusive and decolonial approaches to psychosocial support. Sessions were audio-recorded (consent to record was given) and transcribed verbatim. Also, the co-researchers kept reflective diaries for three months, documenting critical incidents, dilemmas, and innovations related to learner support. Diaries encouraged reflection on how context, culture, language, and power shaped psychosocial and academic support.

Data were analysed thematically using Braun and Clarke's (2006) six-phase framework (familiarisation, coding, theme development, review, definition, and reporting). Initial coding was conducted by the lead researcher, followed by collaborative analysis sessions with the co-researchers to refine and name themes, enhancing credibility and ownership.

5.1. Ethical considerations

Ethical clearance was obtained from North-West University, ethics number NWU-01185-25-A 2. Further permissions were sought and granted by various gatekeepers, including the Department of Education, School Management Teams, and School Governing Bodies. Participants provided informed consent, pseudonyms were used, and attention was paid to emotional well-being during discussions of traumatic experiences.

6. Findings

Three major themes are highlighted here. (Names used below are not the real names of the co-researchers).

6.1. Structural constraints and emotional labour

Teachers emphasised systemic barriers to effective learner support: overcrowded classes, lack of specialist services, food insecurity, and chronic trauma exposure. One teacher thus noted, *"You are not only a teacher; you are a social worker, a parent, a psychologist, but without the training or time. Some days it feels like you are putting a small plaster on a very big wound." (Ms. Thandi)*. The emotional toll of working in high-poverty, high-trauma environments was also evident. *"When a learner tells you they slept without food, you cannot just continue with your science as if everything is normal." (Mr. Dlamini)*

6.2. Local assets and community-linked support

Despite these constraints, teachers identified critical local assets, including strong relationships with families, peer solidarity, and faith-based and community networks. *"The church leaders, the 'makhulus' (grannies), they know these children. When we involve them, it's easier to follow up when a learner is struggling." (Naledi)*. Peer support was also considered powerful, as indicated by one teacher. *"Sometimes another learner can reach them better than we can. We use group work so they can encourage each other, in their academic work and in social life." (Ms. Fefe)*

6.3. Inclusive and decolonial pedagogical strategies

Teachers reported drawing on a range of inclusive strategies, such as differentiated instruction, flexible grouping, scaffolded tasks, and cooperative learning, to address diverse cognitive and psychosocial needs. They actively integrated learners' languages and community knowledge, as thus indicated, *"When I*

explain in Sesotho and use examples from the village, they open up. They feel this subject is also theirs, not only for town children." (Ms. Mpho). Perceptions of a decolonial approach to psychosocial support were emergent but salient. Teachers associated it with valuing local culture, languages, and collective forms of care. *"For me, decolonial support means we don't treat our culture as a problem. We use our traditions of sitting together, listening to elders, praying, to support the child." (Ms. Mamzo). "Most programmes come from outside and expect us to do counselling like in the movies. Decolonial means starting with what our community already uses to heal." (Mr Rara).* Teachers also linked decoloniality to power and voice: *"The learners must see themselves in the stories, in the examples. If they are always hearing other people's lives, they think their own problems are not important." (Lebo)*

7. Discussion

The findings confirm earlier work on the severe constraints facing rural schools (du Plessis & Mestry, 2019; Pillay et al., 2023), but also extend the literature by showing how teachers actively negotiate these constraints through contextually grounded practices and community-linked initiatives. Consistent with CoP theory, teachers are not isolated individuals but members of an emergent practice community that collectively constructs meanings and strategies for learner support (Wenger, 1998; Marongwe & Chisango, 2022). The study also revealed that the emotional labour described by teachers highlights the risk of over-reliance on under-supported teachers, echoing concerns in the wider literature (Mampane, 2020). Without structural investment in professional development, school-based support teams, and intersectoral collaboration, teachers' efforts remain fragile. The findings indicate that teachers' emphasis on community rituals, elders, and faith-based networks challenges purely individualised, therapeutic models and suggests pathways for a more culturally resonant support system. This aligns with scholarly calls to centre indigenous knowledge, local languages, and collective care (Seedat et al., 2009; Zembylas & Chubbuck, 2020), which shows teachers' lay understandings of decolonial psychosocial support in the current study.

8. Conclusions

Learner support in rural South African secondary schools is shaped by deep structural inequalities but is also animated by rich local resources and teacher agency. Teachers in this study conceptualised learner support as both academic and psychosocial, enacted through inclusive classroom strategies and community-linked practices. Their emerging understandings of decolonial psychosocial support emphasise recognising learners' cultural identities, drawing on local forms of healing, and resisting deficit views of rural communities. The study demonstrates that effective learner support in rural contexts requires policy implementation on inclusion and context-sensitive support for teachers and schools.

9. Recommendations and future research

Based on the study's findings, schools should develop ongoing, school-embedded PD programmes that build teachers' psychosocial competencies, grounded in decolonial and inclusive frameworks, using reflective, participatory methods rather than one-off workshops. Schools should also establish or reinforce School-Based Support Teams (SBSTs) in rural schools, with clear mandates and linkages to district-based support and local social services. Create formal partnerships between schools and various community stakeholders to co-design psychosocial support initiatives that respect learners' cultural contexts. The study further recommends that provincial and district resourcing align with policy commitments to inclusion, prioritising rural schools for access to specialist services, nutrition programmes, and psychosocial interventions.

Future studies should extend the PAR approach to include learners and parents as co-researchers to understand psychosocial support from multiple perspectives. Focus can also be on exploring the role of digital and low-tech tools in supporting decolonial psychosocial support in rural settings.

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EDUCATION FOR THE FUTURE IN THE FIELD OF ENERGY SAVINGS AND ENERGY LITERACY

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Abstract

Energy represents an inseparable part of modern life and technological progress. Given the growing demands for sustainability and efficient resource utilization, it is essential that every individual possesses basic knowledge about the proper handling of electrical energy. Inefficient use of electricity leads not only to unnecessary waste but also to economic and environmental losses. The authors of the article defined two main objectives: a research-application objective and a pedagogical objective. The research-application objective of this contribution is to quantify electricity consumption in a university laboratory both in overall terms and for individual specialized appliances and laboratory equipment. The output is a detailed overview of measured values, serving as a basis for analyzing energy demands and identifying potential savings. The pedagogical objective of the article is to develop students' energy literacy through practical understanding of electricity consumption in a laboratory environment, while also enhancing their technical skills in measurement, analysis, and critical evaluation of the energy demands of devices. Emphasis is placed on fostering a responsible approach to energy use, both in professional practice and everyday life, with the aim of seeking efficient and sustainable solutions. The introductory part of the article addresses fundamental aspects of energy, such as the typology of power plants, the development of energy consumption, and electricity pricing. This section provides context for the subsequent analysis of consumption in the laboratory setting. The following section focuses on the technical principles of selected specialized appliances and laboratory equipment. Their detailed description is essential for understanding the energy requirements of individual devices and for accurate interpretation of the measured data. The article also includes an overview of methods for measuring electricity consumption, including descriptions of instruments and procedures used to measure power input. This methodological section forms the foundation for the practical implementation of measurements. The practical part includes specific measurements of power input and consumption for selected devices. The result is an overview of individual appliances and laboratory instruments, supplemented by measured values that enable comparison and identification of energy-intensive components. The final section presents a proposed energy literacy test designed for students working in the laboratory as part of practical exercises. The test is conceived as a tool to raise awareness of the energy demands of specific devices and to support the development of competencies in the sustainable use of energy.

Keywords: *Energy savings, energy literacy, measurement of electricity consumption, handling of electrical energy, typology of power plants.*

1. Introduction

Energy has become a fundamental pillar of modern society, and its importance continues to grow in response to increasing consumption, digitalization, and sustainability demands. Knowledge of electrical energy generation, distribution, and consumption is therefore essential in both technical and non-technical education. In a globalized environment where energy stability and efficiency underpin economic and technological progress, the ability to use energy responsibly is becoming ever more critical.

Growing pressure to reduce energy intensity, minimize losses, and implement efficient solutions is evident across industrial sectors as well as within public institutions. Current studies indicate that the achievement of these goals is strongly influenced by the level of energy literacy and the quality of professional training, as insufficient knowledge and fragmented preparation can lead to unnecessary losses and reduced system performance (Clarke, Gleeson, & Winch, 2017; Brunelli et al., 2025; Piredda et al., 2025). Research also highlights the increasing importance of energy auditing as a strategic tool for

improving energy management, supporting efficient resource use, and reducing environmental impact. Properly implemented audits contribute to energy efficiency, promote the rational use of energy resources, and support sustainable economic and societal development (Tomášková et al., 2023).

At the same time, awareness of renewable energy and sustainable technologies among students in vocational and higher education remains limited, which complicates progress toward broader energy-transition goals (Kacan, 2015; Mukhtar et al., 2020; Drozich, 2023). Studies also indicate that innovation laboratories and educational platforms often struggle to provide applicable technical solutions due to insufficient cooperation between industry and academia (Ponce, Polasko, & Molina, 2019). Digitalization can further intensify energy demand in early phases but later supports greater integration of renewable sources where sufficient human capital exists (Wang et al., 2025).

Given these dynamics, educational institutions must support not only theoretical understanding but also the development of practical, experimentally verifiable skills. Laboratory environments enable students to analyze the energy behavior of devices using real measurements and encourage data-driven reasoning. Such hands-on experience fosters a long-term sustainable, informed, and responsible approach to energy use an essential competency for future professionals in the energy sector and related technical fields.

2. Energy context and fundamental aspects of power engineering

Energy systems form a complex infrastructure that enables electricity generation and use under varying technical and societal conditions. Understanding laboratory energy demand requires only a basic overview of key principles, including types of power plants, long-term consumption trends and the main factors shaping electricity prices. Different energy sources provide varying levels of stability and environmental impact, while the growing share of renewables increases the need for flexibility in the grid. Rising electricity consumption highlights the importance of efficient energy use not only in industry but also in educational laboratories, where demand differs according to equipment and operating modes. Electricity prices depend on technical, market and regulatory factors, and understanding these relationships helps students recognise the economic implications of energy use. Together, these elements provide an essential framework for assessing energy demand in the laboratory and for interpreting measured consumption values of individual devices.

3. Characteristics and operating principles of laboratory equipment

The set of six analysed devices (Table 1) combines traditional machining technologies with modern digitally controlled equipment, enabling a clear comparison of energy behaviour across different categories of laboratory machines. Conventional woodworking and metalworking tools such as the format circular saw, mitre saw and drill presses represent established manufacturing technologies with higher instantaneous power demand and load-dependent fluctuations, making them suitable for illustrating the energy characteristics of classic workshop equipment. In contrast, the CO_2 laser engraver and the Original Prusa i3 3D printer represent contemporary digital fabrication technologies with distinct operating principles and energy profiles. The CO_2 laser shows substantial auxiliary consumption due to cooling and extraction, whereas the 3D printer operates with low and stable long-term power typical of additive manufacturing. By including devices with diverse power ratings and operating modes, the study captures a representative spectrum of energy demands in educational laboratories. This diversity supports both the evaluation of high-consumption equipment and the identification of more energy-efficient technologies, contributing to the development of students' energy literacy and preparing the ground for the subsequent analysis of each device's technical and operational characteristics.

Table 1. Technical Parameters and Comparative Energy Demand of Traditional and Modern Laboratory Machines.

Machine	**Type/Model**	**Power Consumption (W)**	**Motor Power (W)**	**Power Supply (V)**
Format Circular Saw	Holzstar FKS 250-1300	2000	1500	400
Compound Mitre Saw	Metabo KGS 216 M	1500	1500	220 – 240
Column Drill Press	TYP S20A	750/1100	750/1100	380 – 400
Bench Drill Press	FERM FTB-13	350	350	230
CO_2 Laser Engraving	Class IV, CO_2 10.6 μm	700–1000	60 – 100	400
3D Printer	Original Prusa i3	100	40 - 150	230

The format circular saw is strongly affected by blade load, feed rate and idle-running duration, which may account for 5–25 % of its operating time. The mitre saw likewise exhibits notable inrush currents and power fluctuations caused by material hardness and cutting depth. The column drill press shows significant increases in consumption when drilling larger diameters or machining steel due to higher drilling resistance. In contrast, the compact bench drill press demonstrates low inrush currents and minimal mechanical losses, making it a low-energy-demand device. The CO_2 laser engraver exhibits substantial fixed losses from its high-voltage power supply as well as continuous consumption from cooling and extraction systems. Its idle time can reach 20–40 % in educational environments, which significantly reduces overall energy efficiency. The 3D printer displays a stable average consumption of around 100 W, with peaks mainly occurring during initial heating. Additional continuous power draw comes from stepper motors and cooling fans, though at a much smaller scale. These operational characteristics highlight substantial differences in how individual machines convert input energy into productive work. Collectively, they illustrate the need to consider both active and auxiliary consumption when assessing laboratory-scale energy performance.

4. Experimental measurement and analysis

This chapter presents the practical part of the study, focused on measuring and evaluating the electrical energy consumption of selected laboratory devices. The aim is to obtain real data on the energy behaviour of individual machines, compare their operational demand, and identify factors that may significantly influence the overall energy load of the laboratory environment. The collected values provide a foundation for proposing energy-efficient measures and for developing a student energy-literacy test.

4.1. Methodology of electrical energy measurement

The aim of the measurement methodology was to obtain comparable indicators of the operational energy consumption of selected devices under typical workshop or laboratory conditions. The measurement procedure was designed to be simple, safe, and easily repeatable within an educational environment. The measurement was carried out using a plug-in digital wattmeter, which enabled the recording of instantaneous power input (*W*), current (*A*), voltage (*V*), power factor, and cumulative energy consumption (Wh/kWh). A digital multimeter was used to verify the stability of the mains voltage and to perform control readings, while a simple timer ensured consistent timing and synchronisation of all measurement intervals. Each device was tested across defined operating regimes, including the start-up and heating phase, idle operation, operation under load, and the final shutdown or run-down period. This structured approach ensured that the measurements captured both stable and dynamic aspects of the devices' electrical behaviour.

4.2. Results and analysis of electrical energy measurement

The measured parameters include Δt (min) as the measurement duration, *P* (W) as the average power draw, *Pmax* (W) as the peak observed power, and *E* (Wh) as the total energy consumed in the given operating mode (Table 2).

The measurements revealed significant differences in energy consumption between start-up, idle, and load operation. Saws and drill presses show short but intense start-up peaks, while idle operation represents a substantial share of non-productive energy use, especially for the panel saw and the S20A drill press. Under continuous load, woodworking machines maintain high and steady power draw, making overall consumption strongly dependent on cycle duration and workflow organization. The CO_2 laser shows considerable auxiliary demand from cooling and extraction systems, while the 3D printer demonstrates the lowest power consumption with minimal idle losses.

The analysis of the measured data made it possible not only to compare the technical characteristics of the individual devices, but also to identify operational patterns that are not apparent during routine use. The discussion of the results showed that the energy behaviour of the machines is influenced not only by their design and motor performance, but also by the working method, the frequency of start-ups and the organisation of operational tasks. The evaluation of the power-draw profiles confirmed that non-productive energy represents a significant share of the total consumption and constitutes a key area for operational optimisation. These findings have substantial educational value, as they enable students to work with authentic data, critically interpret measured quantities and understand the impact of technical and operational decisions on energy consumption. Moreover, engaging students in discussions about the results supports the development of energy literacy and leads to a deeper understanding of the principles of sustainable laboratory operation. Based on the results, several key areas for energy savings were identified:

- Idle time control (turning off saws and the S20A during breaks; work into continuous cycles);
- Tool and feed optimization (selecting suitable blades or drill bits reduces both cycle time);

- CO_2 laser auxiliary systems (activating extraction and cooling only during active processing; maintaining clean filters);
- Prioritizing low-power technologies (using 3D printing where appropriate instead of high-load subtractive machining);
- Didactic management (teaching students to operate machines in an energy-efficient manner).

Table 2. Results and Analysis of Electrical Energy Measurement.

Device	Mode	Δt (min)	P (W)	P max (W)	E (Wh)
Panel saw FKS 250-1300	Start	1	1600	2000	27
Panel saw FKS 250-1300	Idle	15	900	980	225
Panel saw FKS 250-1300	Load	60	1450	1800	1450
Mitre saw KGS 216 M	Start	1	1200	1500	20
Mitre saw KGS 216 M	Idle	15	250	300	62,5
Mitre saw KGS 216 M	Load	60	1200	1500	1200
Drill press S20A	Idle	15	300	380	75
Drill press S20A	Load	60	900	1100	900
Bench drill FERM FTB-13	Idle	15	120	160	30
Bench drill FERM FTB-13	Load	60	280	350	280
CO_2 laser (Class IV)	Start	3	900	1100	45
CO_2 laser (Class IV)	Engraving	60	750	900	750
CO_2 laser (Class IV)	Cutting	60	950	1100	950
3D printer Prusa i3	Heating	10	180	240	30
3D printer Prusa i3	Printing	60	100	130	100
3D printer Prusa i3	Idle	30	70	90	35

4.3. Student energy literacy test

To evaluate the level of students' energy literacy, a short three-part test was designed. The test reflects the real power-consumption measurements carried out in the workshop and assesses not only conceptual understanding but also the students' ability to interpret real data and apply it in practical situations. The content directly relates to the measured consumption of devices such as the panel saw, mitre saw, drill presses, CO_2 laser, and 3D printer.

4.3.1. Structure of the test: Part A understanding basic concepts. This section verifies whether students understand the basic energy-related concepts used in the consumption measurements applied in the practical experiment. It focuses on their comprehension of quantities such as power P (W), energy E (Wh), and peak load P_{max} as well as their ability to distinguish between operational states such as idle mode, load mode, and machine efficiency. The main goal is for students to correctly differentiate between instantaneous power and total energy consumption, which is essential when interpreting real measurement data.

4.3.2. Structure of the test: Part B interpretation of graphs and measurement data. This section builds directly on the practical measurements of the machines' power consumption and assesses students' ability to interpret the recorded data. Students are required to compare the consumption profiles of saws, the CO_2 laser, and the 3D printer, identify which device exhibits the highest share of idle-mode consumption, and explain why the CO_2 laser shows significant energy use even without active cutting. They also evaluate why 3D printing is more energy-efficient during long-term operation and how the duration of the load mode influences total energy consumption. This part therefore tests their ability to read wattmeter data, compare the parameters P, P_{max} and E, and draw meaningful conclusions from the measured values.

4.3.3. Structure of the test: Part C practical application in the workshop. The tasks in this section build directly on the results of the practical measurements and assess whether students can apply the collected data in real workshop contexts. Working with specific examples from the measured operating modes, students propose strategies to reduce the energy consumption of the panel saw during class, such as limiting idle operation or organising work into continuous cycles. Furthermore, students justify why 3D

printing serves as a low-energy alternative for certain tasks and determine, based on the measurements, which device exhibited the highest idle consumption and how this can be addressed. This section therefore evaluates their ability to connect theory with practice, interpret measurement data, and propose energy-efficient operational strategies.

5. Conclusion

This study demonstrated that developing students' energy literacy is essential for their future professional and civic responsibilities. The practical measurements of energy consumption served primarily as a didactic tool that enabled students to understand how electrical energy behaves in real technological processes. Rather than being the main outcome of the research, the measured values acted as a means through which students learned to interpret data, think critically about it, and draw conclusions about the energy efficiency of different technologies. The pedagogical contribution of the study lies in giving students the opportunity to connect theoretical concepts with concrete situations in the workshop. They learned to distinguish between instantaneous power and total energy consumption, to recognise differences between idle operation and load conditions, and to reflect on how their own working procedures influence energy demand. The instructional approach also encouraged students to consider broader contexts—from responsible energy use to sustainable decision-making when selecting technologies and operational strategies. The proposed student energy-literacy test made it possible to evaluate not only their theoretical knowledge but especially their ability to apply what they learned in practice, identify sources of energy waste, and propose effective, rational, and sustainable solutions. This integration of experimental experience, data interpretation, and pedagogical guidance supports a deeper understanding of energy principles and helps shape responsible future technicians, educators, and users of technology.

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COULD YOU TEACH ME HOW TO THINK?

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Abstract

One of the core values of education, at any level, should be critical thinking. We educate students so that, with their knowledge, they can act critically in their future professional careers and in life in general. However, do we actually teach students to learn how to think? In science and engineering programs, through subjects such as Mathematics or Physics, students are trained to approach problems and to apply logical reasoning to find possible solutions. But we don't teach them to reflect on their own learning, as is done in other, more education-oriented disciplines. Experience has shown that, in general, university students do not used to stop and critically think about their own learning process. In this paper, we present how we have guided university students from various science and engineering degrees in the process of reflecting on their learning experiences and the skills acquired during Service-Learning (SL) projects. The study involves twenty undergraduate students who participated in a one-week SL activity in Morelia, Mexico. The program was integrated in an international and interdisciplinary initiative under the Erasmus+ Project G.I.R.L.S. (Generation for Innovation, Resilience, Leadership and Sustainability), which brought together students from the sciences, engineering and health sciences from the partner countries involved in the project. The activities covered a wide range of topics, from hygiene education to collaborative community-based interventions. The SL methodology includes well-defined phases: observation, preparation, action, reflection, recording, evaluation, and acknowledgments. It has been observed that, although most of these phases do not present difficulties for students, the bottleneck is during the reflection part. To facilitate the reflective process, a comprehensive guide outlining the phases of the project was first developed, together with guidelines designed to support the internalization and implementation of SL projects and their methodology. In addition, to delve deeper into the experience, reflection sessions were conducted in four stages: individual reflection, reflection in small groups, collective reflection in a large group, and a final reflection about future action, guided by selected questions. At the beginning of the process, students appeared to engage with their experiences at a superficial level; nevertheless, as the reflection activities advanced, they progressively demonstrated greater depth in their analysis and understanding. The results highlight the importance of promoting higher education environments that enable students to develop the competencies and strategies required for more meaningful engagement in their own learning processes.

Keywords: *Service-learning, critical thinking, reflection, higher education, science/engineering education.*

1. Introduction

One of the core values of education, at any level, should be critical thinking. We educate students so that, with their knowledge, they can act critically in their future professional careers and in life in general. However, do we actually teach students to learn how to think? In science and engineering programs, through subjects such as Mathematics or Physics, students are trained to approach problems and to apply logical reasoning to find possible solutions. But we don't teach them to reflect on their own learning, as is done in other, more education-oriented disciplines. Experience has shown that, in general, university students do not used to stop and critically think about their own learning process.

Science and engineering programs typically fail to teach students metacognitive skills and critical self-reflection about their learning process. Multiple studies substantiate this claim. May and Etkina (2002) found that students rarely reflect on how they learn specific content, with most lacking sophisticated epistemological awareness. Hernán Paz Penagos (2011) specifically noted that while students master problem-solving procedures, they do not develop self-knowledge about their learning abilities.

Wynne (2010) further revealed that students often do not value reflective activities, preferring traditional analytical assignments. The evidence suggests a systemic gap in engineering and science education, where technical problem-solving skills are prioritized over understanding one's own learning mechanisms. Developing metacognitive skills could potentially enhance students' conceptual understanding and long-term learning capabilities. Turns (2014) emphasizes the importance of integrating reflection into engineering education, focusing on teaching reflective practices and metacognitive awareness, which addresses the gap in teaching students to reflect on their own learning in science and engineering programs.

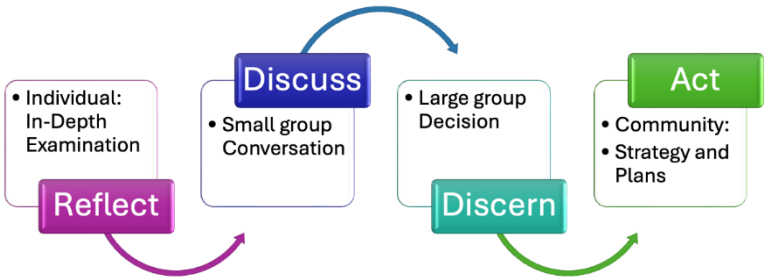
In this paper, we present how we have guided university students from various science and engineering degrees in the process of reflecting on their learning experiences and the skills acquired during Service-Learning (SL) projects. The study involves twenty undergraduate students who participated in a one-week SL activity in Morelia, Mexico. The program was integrated in an international and interdisciplinary initiative under the Erasmus+ Project G.I.R.L.S. (Generation for Innovation, Resilience, Leadership and Sustainability), which brought together students from the sciences, engineering and health sciences from the partner countries involved in the project (GIRLS, 2026).

2. Methodology

The Erasmus+ Project G.I.R.L.S. is a collaborative European initiative aimed at promoting inclusion, diversity, gender equality, digital transformation, and the Sustainable Development Goals. By integrating active methodologies such as research-based learning, game-based learning, competency-based learning, and service-learning, the project encourages both students and educators to engage in experiential learning, creativity, and leadership development (Hernández Encinas et al., 2025). This paper focuses on the Service-Learning methodology and how it can be used to foster reflection on learning among students. Specifically, we will analyze the experience carried out in the Michoacán, region of Mexico, with 20 students from four different countries (Portugal, Romania, Spain, and Mexico): thirteen engineering students, four health sciences students, and three students of Translation, Interpreting, and Language Teaching. The activities included hygiene education, public health campaigns, and collaborative problem-solving through statistical analysis with community members. The pedagogical design followed the principles of active learning and intercultural exchange. These students had already participated in Service-Learning projects at their universities (Rasteiro et al., 2025). The students involved belong to the University of Salamanca, USAL, (Salamanca, Spain), Francisco de Vitoria University, UFV, (Madrid, Spain), the Polytechnic University of Coimbra, IPC, (Coimbra, Portugal), the Technical University of Civil Engineering in Bucharest, UTCB, (Bucharest, Romania) and Vasco de Quiroga University, UVAQ (Morelia, Mexico).

The SL methodology includes well-defined phases: observation, preparation, action, reflection, recording, evaluation, and acknowledgments. It has been observed that, although most of these phases do not present difficulties for students, the bottleneck is during the reflection part. To facilitate the reflective process, a comprehensive guide outlining the phases of the project was first developed, together with guidelines designed to support the internalization and implementation of SL projects and their methodology (https://girlsproject.eu/wp-content/uploads/01-Service-learning-guide_EN_v2.pdf).

Figure 1. Stages for reflection, individually and in groups, on the learning achieved through the SL projects carried out in Michoacán (Mexico).



The Vasco de Quiroga University campus in Morelia was responsible for coordinating all activities carried out during the exchange program in Mexico. Visits were made to the towns of Ciudad Hidalgo and Patzcuaro to develop various service-learning projects that the students had been preparing beforehand, thanks to information provided by professors at the UVAQ. Details of all the activities can be found on the GIRLS project website (https://girlsproject.eu/mexico/). As previously mentioned, three student groups were formed to carry out SL Projects:

- Team 1 (IPC and UTCB): “Statistics: How to prepare a survey and collect data”.
- Team 2 (USAL and UVAQ): “Experiments to understand the importance of hygiene, based on scientific evidence”.
- Team 3 (UFV and UVAQ): “Basic pre- and postpartum physiotherapy”.

Following the implementation of the projects in Ciudad Hidalgo, we conducted an initial phase of guided reflection with the students. To delve deeper into the experience, the reflection sessions were carried out in four stages. (Figure 1):

i. Reflect. The first step is individual reflection, which invites everyone to ask essential questions about the learning experiences at all stages of the Service-Learning project (Figure 2a)).
ii. Discuss. The second step involves sharing these reflections in small groups, without judgment (Figure 2b) and 2c)).
iii. Discern. The third step is sharing the key elements that emerged in each group with the entire school community (Figure 2d)).
iv. Act. Finally, the fourth step is to collectively identify the relevant elements for the future that will improve the Service-Learning experience. The important thing is not so much what the decision is, but that it is the fruit of communal discernment.

Once the second intervention in Patzcuaro took place, the reflection session with the students was repeated, following the scheme proposed in the first one.

3. Discussion

At the beginning of the process, the students' reflections focused more on sensations or feelings than on the learning itself. As an example, we have compiled some of their impressions, which we present according to the type of grouping in which they were carried out (individual, small group and large group).

Figure 2. Different results and moments of reflection: a) individual, c) in small groups, e) in large groups; as well as an image of a moment when the students shared the reflection in small groups.

- In individual reflection (Figure 2a)):
  - *“I feel a bit nervous but excited to know people and help”.*
  - *“I had no expectations but every one was so nice that it was easy to have pride”.*
  - *“I felt lately better than I've expected. It seems like I found a new family”.*
  - *“Great fun and the chance to interact and get closer to the community, serve the people”.*
- Small group reflections:
  - *“Comfort. Reality Check. Bonds / Friendships. Culture. Cooperation. Impact. Experiences. Multiculture. Diversity. Firm - Tequila, Mixed. Support. Union. Freedom / Freedom of speech".*
  - *“Sharing the same feelings about the safe space created, empathy and kindness, our hearts were moved by emotion”.*

- Community reflections:
  - *"Friendship".*
  - *"The power and the kindness of the humanity is beautiful!".*

As teachers helped them focus on the topic, their reflections became deeper. And without a doubt, they all reflect the great transformative power that service-learning projects have on students.

- In individual reflection:
  - *"Acknowledgement of our skills and abilities and knowing that we have much to offer".*
  - *"Conscious about our role as a bridge between the university, people and community".*
  - *"The service-learning activity was really good, very organized, involving both theory and practice. The environment was very friendly and welcoming. The preparation was good, based on past videos and presentations that resumed exactly the important things. The experiments were the best impacts because they were an approximation of theory".*
  - *"The potential impact is way bigger than expected. The amount of love and hunger expressed by the locals made me feel motivated and excited. I am insatiable now to help more with my knowledge".*
- Small group reflections:
  - "*We have learned something we didn't notice about our degree, that is we always open our heart to the people and receive them with open arms. And it is overwhelming seeing that these persons open their heart to us in respond of our actions".*
  - *"As a group the project has exceeded our expectations. First of all, we are surprised by how our differences made us stronger and how every idea has been heard, and everyone had an important part on the project. We all agreed that we feel joy from being able to make a difference in the real world and we would love to help even more in the future".*
- Community reflections:
  - *"Grateful to have the opportunity to learn & share with so fantastic people."*
  - *"To change, to learn, to help, is to live".*
  - *"Serving, connecting, helping... together we make a brighter future possible".*

Based on the analysis of the reflection murals created by the participants, the following main conclusions can be drawn, summarizing the impact and lessons learned from the Service-Learning experience:

- The Human Factor and Emotional Connection. The most powerful conclusion is the deep emotional connection established with the local community. Participants describe feelings of "love," "joy," and "gratitude". The warmth of the Mexican community is highlighted, with participants mentioning that they "opened their hearts" unexpectedly. The recurring phrase "giving is receiving" summarizes the feeling that the students received more life lessons than they themselves contributed technically.
- The Awakening of Social Vocation. The project has served as a "reality check" that has transformed the students' professional vision. Many mention a "change of mindset" after applying their technical knowledge (from their academic degree) to real health and sanitation problems. There is a sense of "insatiable desire" to continue helping, the impact seen in the community has served as a source of intrinsic motivation.
- Synergy and Teamwork (Multiculturalism). The group mural highlights how the diversity of backgrounds and disciplines became a strength. It is mentioned that individual differences made the group stronger. The team managed to create a "safe space" of mutual support, where communication flowed despite initial language and cultural barriers.
- Community Empowerment. A key conclusion, especially reflected in the notes in Spanish, is the focus on community autonomy. The project is not perceived as an external, paternalistic intervention, but rather as a process where the community must be "the initiator of its own change". The ultimate goal expressed is that the work carried out will have continuity and achieve a tangible goal for the well-being of the residents.
- Personal Growth and Self-Knowledge. On an individual level, the experience was a challenge that exceeded all expectations. The participants transitioned from initial uncertainty and nervousness to a sense of pride and peace. The creation of lasting friendships ("a new family") and the discovery of personal skills they were unaware of before the fieldwork were highlighted.

As can be seen, at the end of the reflection, the students have really been able to internalize the learning that the Service-Learning methodology has provided them, while at the same time the great transformative power of this methodology is very well described.

4. Conclusions

The results of this study highlight that the implementation of Service-Learning projects in science and engineering degrees is a powerful tool not only for acquiring technical competencies but, fundamentally, for "teaching university students how to think". Based on the analysis of the experiences of the group in Morelia, the following main conclusions can be drawn.

Firstly, it is evident that structured reflection is the indispensable mechanism for transforming a field experience into meaningful learning. Without a guided reflection framework across multiple stages (individual, small group, and collective), students tend to remain at a superficial level of analysis centered on immediate emotions. The transition from "sensation" to "critical thinking" requires pedagogical mediation that challenges students to confront their technical knowledge with social reality.

Secondly, SL methodology acts as a catalyst for metacognition. Through these projects, students from technical backgrounds—accustomed to logical-mathematical reasoning—successfully identify their own knowledge gaps while simultaneously discovering transversal and vocational skills that the conventional classroom fails to awaken. This "reality check" fosters a much more human and committed vision of the profession.

Finally, the process of "communal discernment" reinforces the idea that service is not a unidirectional action, but a process of mutual empowerment. By teaching students to reflect on future action, they are prepared to become professionals capable of listening and responding to the needs of the community, promoting a mindset that moves beyond individual success to focus on the social impact of their expertise.

In conclusion, this work demonstrates that it is both possible and necessary to integrate critical thinking education into science careers. SL, supported by deep reflection, constitutes one of the best strategies for training not only competent engineers or scientists but also citizens capable of reflecting on their own learning process and their role in society.

Acknowledgments

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RECONCEPTUALIZING HUMANITIES PEDAGOGY IN CONTEMPORARY AMERICAN UNIVERSITIES: CULTURE, LITERATURE AND FOREIGN LANGUAGES IN TRANSITION

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Abstract

American universities are undergoing a significant pedagogical shift, particularly in literature, cultural studies, and foreign language programs. Rapid technological change, evolving cultural landscapes, and the educational disruptions of the COVID-19 pandemic have intensified longstanding debates about the place and purpose of the humanities. At the same time, changing student expectations, new administrative models, and the decline of strictly lecture-based instruction have reshaped how we teach, interpret texts, and define intellectual authority in the classroom. This paper situates these developments within a cross-disciplinary dialogue that connects institutional restructuring with classroom practice. Focusing on English literature, cultural studies, and foreign language instruction, it examines how cultural and linguistic interpretation, especially through themes of ethnicity, gender, migration, and multilingualism, can foster deeper literary understanding and civic awareness. Drawing from both pedagogical theory and sustained classroom experience, the study explores the intersections of curricular reform, translingual pedagogy, and institutional change. It argues for student-centered models that sustain critical inquiry, interpretive rigor, and social responsibility in today's university environment.

Keywords: *Higher education, curriculum design, inclusive pedagogy, multilingual learners, instructional innovation, institutional reform, teaching and learning, language education.*

1. Introduction

American higher education is in the midst of reassessing not only what the humanities teach, but how and why they teach it. Literature, cultural studies, and foreign language programs, once viewed as foundational to the development of ethical reasoning, interpretive skills, and civic awareness, now face renewed scrutiny regarding their relevance in a rapidly changing social and political climate.

The COVID-19 pandemic accelerated trends that were already underway. Digital learning environments, hybrid instruction, and technological mediation have permanently altered classroom dynamics. At the same time, political tensions surrounding diversity, equity, and the value of the humanities have intensified public debates about the humanities' role. These pressures converge with generational shifts: students increasingly seek interactive, culturally resonant, and personally meaningful educational experiences rather than passive absorption of canonical knowledge.

Traditional lecture-centered models and hierarchical structures of university administrators and professors' authority, while historically significant, often fail to address these evolving expectations. Moreover, students shaped by pandemic-era education and their digital immersion approach to learning, through frameworks of relevance, collaboration, and reflexivity, are constantly seeking a space for dialogue about identity, gender, language, power, media, and lived experience.

This paper argues that the future of humanities pedagogy lies not in abandoning interpretive rigor, but in rethinking how interpretation is practiced. By integrating textual, linguistic, and cultural analysis within participatory frameworks, educators can cultivate both intellectual depth and civic engagement.

2. Methodological approach

This paper draws on sustained teaching experience across literature, cultural studies, and foreign language classrooms in in-person, online, and hybrid settings. Rather than proposing an abstract pedagogical model, it reflects on concrete instructional practices implemented in cross-listed courses, multi-level language classes, and stacked undergraduate seminars.

The analysis is grounded in experiential and participatory learning approaches that emphasize dialogue, collaborative interpretation, and multilingual engagement. By situating everyday classroom practices within broader institutional transformations, this paper demonstrates how pedagogical innovation often emerges from necessity: enrollment shifts, departmental mergers, technological transitions, and changing student demographics.

These developments have reshaped the classroom from a space centered on authoritative transmission into one oriented toward collaborative meaning-making, because the student population is constantly changing. It states that students increasingly see themselves not only as learners of texts, but also as interpreters whose linguistic and cultural backgrounds inform their intellectual inquiry.

3. Institutional restructuring and program transformation

Across American higher education, English, Cultural Studies, and Foreign Language departments have been restructured, merged, or redefined. While budgetary pressures and enrollment decline frequently motivate these changes, they also reflect a broader disciplinary evolution. Programs are moving away from strictly national or canonical frameworks toward transnational, multilingual, and interdisciplinary models.

Such restructuring can generate anxiety about disciplinary identity. Yet it also creates opportunities for curricular innovation. When culture, English, and language programs collaborate, courses naturally expand beyond single traditions and begin to foreground migration, diaspora, translation, and intercultural exchange.

Boyer's (1990) reconceptualization of scholarship provides a useful lens for understanding this transition. By valuing integrative and applied knowledge, institutional restructuring has encouraged Cultural Studies, English literature, and Foreign Language programs to emphasize intercultural competence, translation, and global literacy. While such changes may challenge traditional disciplinary identities, they also create opportunities for pedagogical innovation and interdisciplinary collaboration.

3.1. Classroom example

Following the merger of English and Languages into a single department, at Commonwealth University of Pennsylvania, new literature courses were designed around themes such as ethnic identity, emigration, Caribbean writing, and international short fiction. Students compared texts across linguistic traditions, engaging questions of postcolonialism and displacement. The institutional change, initially administrative in nature, ultimately broadened interpretive possibilities in the classroom.

4. From separation to integration: Language, literature and culture

Foreign language curricula have traditionally separated grammar instruction from literary and cultural study. Lower-level courses emphasized structure and communicative competence, while advanced courses introduced canonical texts. This division often reinforced the idea that language is merely a technical system, detached from cultural meaning.

Recent curricular models challenge that separation. Increasingly, literary, cinematic, and digital materials appear at all levels of instruction, embedding language learning within historical and cultural contexts. Language becomes not simply a tool for communication, but a medium of identity, ideology, and lived experience.

4.1. Classroom example

In cross-listed Latinx culture and literature courses, students analyzed contemporary texts alongside discussions of migration, bilingualism, and U.S. language politics. Multilingual readings, comparative essays, and digital media analysis allowed students to see language as a dynamic cultural practice. End-of-semester reflections consistently revealed that students experienced deeper engagement when linguistic and cultural analysis were integrated rather than compartmentalized.

5. Translingual pedagogy and multilingual classrooms

One of the most meaningful shifts in recent years has been the emergence of translingual pedagogy. Rather than treating multilingualism as a challenge to be corrected, this approach recognizes students' linguistic repertoires as intellectual assets.

Canagarajah (2013) argues that translingual practice reflects the lived realities of multilingual speakers in globalized academic spaces. In the new Culture, English literature, and Foreign language classrooms, translingual pedagogy reshapes both language instruction and literary analysis by encouraging

students to move across languages and cultural frameworks while learning about cultures and literary productions. This approach not only enhances linguistic awareness but also supports equity-oriented teaching by validating diverse linguistic and cultural identities.

In practice, this means encouraging translation, cross-linguistic reflection, and negotiation of meaning. It also means questioning rigid native-speaker norms and acknowledging that language operates within cultural and political frameworks.

5.1. Classroom example

In a Spanish Caribbean literature seminar, heritage Spanish speakers and English-dominant students collaborated on translating contemporary poetry. Through reflective journals and structured debate, students examined how meaning shifts across languages and how translation reveals cultural nuance. The classroom became a space where multilingual identities were not peripheral but central to interpretive inquiry.

6. Student populations and instructional modalities

Today's classrooms include heritage speakers, multilingual domestic students, international students, and adult learners. These layered linguistic trajectories challenge traditional placement systems and require flexible instructional design. Cultural Studies, English literature, and Foreign Language programs have also been transformed by changing student demographics. Contemporary culture, language, and literature classrooms are increasingly inclusive of heritage speakers, international students, multilingual domestic students, and nontraditional learners. These populations challenge deficit-based placement models and require pedagogical approaches that acknowledge the uneven and layered nature of language development. Simultaneously, online and hybrid instruction has become an integral part of those programs. While culture, language, and literature teaching have traditionally emphasized face-to-face interaction, research on blended learning suggests that carefully designed online environments can support meaningful communicative practice and cultural engagement (Garrison & Vaughan, 2008). The coexistence of in-person and online modalities has prompted educators to rethink participation, assessment, and digital literacy.

6.1. Classroom example

During the pandemic, an online comparative culture course incorporated collaborative annotation tools, synchronous discussions, and multimedia analysis of Argentine cultural production, including tango performance. Students engaged in asynchronous reflections and comparative translation exercises, demonstrating that meaningful dialogue can persist beyond physical classrooms.

7. Multi-level and cross-listed models

Institutional pressures and diverse enrollments have led many Cultural Studies, English Literature, and Foreign Language programs to adopt multi-level language classes, stacked undergraduate–graduate courses, and cross-listed interdisciplinary offerings. Multi-level classes bring together students with varying proficiency levels and rely on differentiated outcomes and collaborative learning. On the other hand, stacked undergraduate-graduate classes from different disciplines provide the opportunity to expand course offerings and interdisciplinary collaborations. From a pedagogical standpoint, such models align with sociocultural changes in the population that emphasize scaffolding and peer interaction among different ethnic groups and disciplines.

Stacked and cross-listed courses further reflect institutional goals of efficiency and interdisciplinarity. When thoughtfully designed, these structures can enrich pedagogy by fostering dialogue across academic levels and disciplinary perspectives. However, they also require careful attention to equity, workload, and assessment to ensure pedagogical effectiveness.

7.1. Classroom example

In a multi-level Spanish Business and Law course, heritage bilingual students partnered with advanced non-native speakers to lead discussions and develop research projects. Peer collaboration bridged linguistic differences and reinforced shared intellectual responsibility. When thoughtfully structured, such courses move beyond efficiency measures and become sites of enriched learning.

8. Conclusion

The transformation of literature, cultural studies, and foreign language programs reflects broader institutional and cultural shifts within American higher education. While restructuring and technological change present challenges, they also create openings for renewal.

The central task of this paper is not to defend the humanities nostalgically but to rearticulate their relevance through pedagogies that integrate linguistic diversity, cultural complexity, and interpretive rigor. Student-centered, multilingual, and interdisciplinary approaches do not dilute intellectual standards; rather, they strengthen them by aligning scholarly practice with the lived realities of contemporary learners.

In this evolving academic landscape, the humanities remain essential, not as static guardians of tradition, but as dynamic spaces for critical thought, cultural dialogue, and civic responsibility.

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ANALYSIS OF ACADEMIC DISCOURSE ON SUSTAINABILITY THROUGH NATURAL LANGUAGE PROCESSING (NLP)

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Abstract

This research examines the predominant conceptual frameworks in international academic literature on corporate sustainability and assesses their alignment with the principles of Environmental Education for Sustainability. Using a mixed-methods design applied to a corpus of 604 high-impact articles indexed in Scopus (2023-2024), we combined quantitative n-gram analysis through Natural Language Processing (NLP) with qualitative framing analysis. This approach enabled the identification of the most frequent terms and phrases (1, 2, and 3-word combinations), as well as the interpretation of their discursive context and underlying logic. The results reveal an academic discourse predominantly structured around corporate-financial logic. The marked prevalence of terms such as "sustainability," "company," and "corporate" among the most frequent 1-grams, together with the recurrence of bigrams like "financial performance" and "corporate social responsibility," demonstrates an approach that subordinates sustainability to management and profitability objectives. Contextual analysis confirms that these concepts are primarily framed as instruments for risk management and economic value maximization, marginalizing essential perspectives such as environmental ethics, climate justice, and planetary boundaries. It is important to acknowledge that the study is limited to English-language literature indexed in Scopus, which may exclude valuable perspectives published in other languages or regional journals. Furthermore, although n-gram analysis provides robust identification of discursive patterns, its quantitative nature requires complementary qualitative contextual analysis to adequately interpret underlying meanings. Based on these findings, the results highlight the need to incorporate "critical discourse literacy" into Environmental Education for Sustainability programs. We propose training future leaders in deconstructing the identified hegemonic narratives—which subordinate sustainability to financial logic—to foster more autonomous, critical, and systemically transformative ecological literacy.

Keywords: *Sustainability education, discourse analysis, Natural Language Processing (NLP), epistemic bias, finance and sustainability.*

1. Introduction

Environmental education is critical for the development of ecological literacy and promotion of responsible behavior. The primary focus of education *for* the environment is the development of environmental ethics and a sense of responsibility aimed at conservation. Environmental education provides the human and cultural values, skills, and system thinking needed to implement the corporate responsibility frameworks such as the Triple Bottom Line (TBL), Stakeholder Theory, and Resource-Based View (RBV). The connection between environmental education and corporate responsibility is often explored through organizational learning, corporate social responsibility (CSR) in education, and Education for Sustainable Development (ESD).

Academic discourse on sustainability combines environmental, social, and economic aspects within ESD. ESD focuses on long-term solutions for human well-being and interconnected challenges. Environmental Education for Sustainability (EEfS) provides an essential ecological foundation that serves as a pathway toward the broader framework of ESD. Academic discourse on sustainability has foundations in Sustainable Development Goals (SDGs), presented by the UN in 2015 and received global commitment by 193 countries on 17 goals with 169 targets for 2030. Within the SDG framework, Quality Education comes under pillar 4, that requires data, research, and educated professionals. EEfS uses modern education to implement the principles of the SDGs (UN, 2016). The World Economic Forum's 2019/2020 report also

emphasizes on sustainability through research and policy development, as the Global Competitive Index (GCI) includes higher education and training as Pillar 5 in its 12 pillars.

The Environmental Education for Sustainability (EEfS) is the transfer of knowledge, ethics, and behaviors essential for environmental sustainability. It is a value-driven education that requires lifelong learning, action, and reflection. EEfS is based on principles that represent the response of education to global ecological crises. The core principles of environmental education for sustainability can be categorized into four groups: Foundational, Pedagogical, Socio-Cultural, and Process-Oriented.

The foundational principles of EEfS have a philosophical basis in holistic and interdisciplinary, lifelong learning, and systems thinking approaches (Nasibulina, 2015; Tilbury, 1995). The holistic and interdisciplinary approach considers that education must integrate environmental perspectives across all subjects, so that the learners can detect connections and understand trade-offs between ecological and socio-economic systems (Tilbury, 1995). The lifelong learning process is the environmental education that includes formal settings and informal contexts like community programs and vocational training (Huckle & Sterling, 1996). Lastly, systems thinking is defined as the understanding of a series of complex and interconnected systems, that considers the environment in its totality of interdependent surroundings rather than just nature (Putilova et al., 2023).

The pedagogical approaches are used to apply foundational principles of EEfS. The pedagogical approaches include experiential and place-based learning, learner engagement and empowerment, and critical thinking and reflection. The experiential and place-based learning approach is direct, firsthand experience and learning in local landscapes, and community, using them as a foundation for study the curriculum. Learner engagement and empowerment occurs where learners actively engage in the teaching/learning process and improve decision making on sustainability issues. Lastly, the education should support critical thinking and reflection for learners to enable them to review cultural, economic, and political values and assumptions that may undermine the ecological systems (Tilbury, 1995). The socio-cultural dimensions and process-oriented principles are essential for inclusion and social justice, ensuring that education addresses environmental inequities and empowers all learners through participatory and collaborative approaches (UNESCO, 2020).

This study explores academic discourse on EEfS by characterizing key research and conceptual frameworks in international academic literature. The study uses qualitative framing analysis as a diagnostic tool to examine the academic discourse. It aims to identify the shortcomings in corporate sustainability literature using n-gram analysis through Natural Language Processing (NLP). It reveals the underlying values and assumptions and proposes critical discourse literacy as a pedagogical outcome of the critical thinking and reflection principle. Critical discourse literacy focuses on the educational outcome of the research. This discourse is necessary to equip individuals with the knowledge, skills, and values needed to address environmental challenges and promote sustainable development.

The rest of the paper is structured as following. Section 2 reviews the existing literature related to this article, while Sect. 3 presents the methodology. Section 4 focuses on results and discussion and finally, Sect. 5 concludes.

2. Literature review

The study of academic discourse on Corporate Social Responsibility (CSR) in sustainability is related to a number of other works in the literature, which can be grouped into three categories: (i) NLP methodologies in sustainability discourse analysis, (ii) Corporate-financial logic and environmental ethics, climate justice, and planetary boundaries, and (iii) Critical discourse literacy in Environmental Education for Sustainability (EEfS). Each of these categories are reviewed below in connection with the present study.

The n-gram analysis in NLP has become a foundational method for capturing sequences of **n** words. Amaliyah et al. (2025) show the application of n-gram models with Support Vector Machine (SVM) classifiers to identify patterns of misleading environmental communications in oil and gas industry sustainability reports. Wahyudi & Alamsyah (2025) use NLP to study public discourse on the adoption of green products in emerging economies. Furthermore, using meta-analysis, Asatani et al. (2020) apply multiple NLP techniques to map research trends about sustainability and SDGs. This study relates to the above-mentioned literature as it applies the NLP method, which will serve as a pedagogical tool for developing critical discourse literacy. These methodological contributions provide the analytical approach adopted in this study.

Conti et al. (2025) conduct keyword analyses of the Chinese ESG reports and show how linguistic choices develop particular human-nature relationships and environmental responsibilities. Park et al. (2023) explore the CSR and ESG literature and show a thematic dominance of corporate actors, stakeholder management, and governance frameworks, with limited structural critique and limited engagement with climate justice. Wells et al.'s (2021) analysis shows that corporate discourse considers sustainability as a

matter of brand management and stakeholder relations. This literature review shows that corporate-financial logic dominates contemporary sustainability discourse. Environmental ethics, climate justice frameworks, and planetary boundaries discourse is marginalized in mainstream sustainability communications. Critical discourse analysis examines how this dominance is reflected and reinforced through language.

Critical discourse analysis (CDA) provides an understanding of how language in the academic discourse operate particularly by emphasizing certain understandings of the sustainability concept while marginalizing others. Several studies apply CDA to show how corporate and policy texts have neutralized critique and preserved business-friendly governance conditions (Wells et al., 2021; Küfeoğlu, 2022). Nervino et al. (2025) show, by using corpus-assisted discourse analysis that sustainable finance discourse emphasizes financial returns and risk management over ethical obligations. Asatani et al. (2020) reveal that goals related to economic development receive more research attention compared to those focused on ecological integrity or social justice. Funk et al. (2024) consider SDG achievement and research attention to show that the academic discourse may not effectively translate into sustainability outcomes. Lee et al. (2023) compare ESG discourse in news versus academic literature and find that both emphasize governance and financial dimensions over environmental ethics or social justice. Critical discourse literacy is the capacity to identify, examine, and challenge the assumptions embedded in dominant discourses, and is proposed here as a key pedagogical outcome of EEfS. Given the dominance of corporate-financial logic in the reviewed literature, this study suggests that EEfS should incorporate critical discourse literacy to help learners question and challenge dominant sustainability narratives.

3. Methodology

The study adopted a mixed-methods design structured around an explanatory sequential logic, meaning that quantitative findings were generated first and then used to guide and deepen a subsequent qualitative inquiry. This sequencing was deliberate: the large-scale statistical identification of dominant terms provided the analytical scaffolding upon which discursive interpretation was later built. The corpus comprised 604 scientific articles indexed in Scopus during 2023 and 2024, a period chosen to capture the most recent consolidation of scholarly vocabulary in corporate sustainability research. Restricting the dataset to Scopus-indexed, English-language publications ensured indexing consistency and comparability across sources, though it necessarily excludes contributions published in other languages or in regional journals not covered by that database.

In the first, quantitative phase, the full text of each article was subjected to Natural Language Processing (NLP) techniques using Python. Text cleaning followed a standardized pipeline: lemmatization was applied to reduce each word to its morphological root, and stopwords were removed using customized lists that went beyond generic English function words to also exclude discipline-neutral academic terms unlikely to carry substantive meaning in the sustainability domain. Following this preprocessing, unigrams (single words), bigrams (two-word sequences), and trigrams (three-word sequences) were extracted and counted using the CountVectorizer function. This n-gram approach captures not only isolated concepts but also their most frequent collocations, providing a richer picture of how ideas cluster and co-occur in the literature than frequency counts of individual terms alone could offer.

The second phase introduced qualitative framing analysis, conducted with the assistance of NVivo software. The focus shifted from raw frequency to discursive context: rather than simply noting that a given term appears often, the analysis examined how it was used, in what argumentative position, and alongside what other concepts. This examination concentrated on three structurally strategic sections of each article, specifically the abstract, the introduction, and the conclusions, since these are the spaces where authors most explicitly articulate their conceptual framing and normative orientation. The analytical objective was to characterize the predominant semantic frameworks shaping the field, identifying whether sustainability was positioned as an intrinsic societal imperative or, conversely, as an instrumental variable subordinate to organizational and financial goals.

In the third and final phase, quantitative frequency data and qualitative framing findings were systematically triangulated. This integration step is methodologically essential: frequency distributions reveal what the field talks about most, but they cannot, by themselves, explain what those conversations mean or what values and assumptions underpin them. Triangulation provided the interpretive bridge between the statistical patterns and their discursive significance, ensuring that conclusions rested on mutually reinforcing evidence rather than on either type of analysis alone.

4. Results and discussion

The frequency distributions generated by the n-gram analysis paint a consistent and revealing picture of how corporate sustainability is currently framed in high-impact academic literature. Among unigrams, the term “sustainability” emerged as the most frequent by a wide margin (66,473 occurrences), which is unsurprising given the corpus. What is analytically significant is the company this term keeps: “company” (57,091) and “corporate” (39,380) rank as the second and third most frequent terms, while “financial” (17,262) also appears prominently. This pattern already signals that sustainability, in this body of literature, is not primarily discussed in ecological or ethical terms but rather as a property or attribute of the corporate form.

The bigram frequencies reinforce this reading with considerable force. The most frequent two-word sequences are “social responsibility” (9,035), “corporate social” (8,107), and “corporate sustainability” (6,318), with “financial performance” (4,349) appearing as another high-frequency collocation. The preponderance of “corporate social responsibility” as a conceptual anchor, confirmed by its trigram frequency of 6,795 and thus by far the most common three-word phrase in the corpus, is analytically significant. CSR is a framework historically developed to articulate the voluntary obligations of firms toward society, but its near-ubiquity here points to a disciplinary tendency to conceptualize sustainability almost exclusively through the lens of what it means for and to the firm. Sustainability thus enters academic discourse less as a systemic imperative rooted in thermodynamic limits, biodiversity thresholds, or intergenerational justice, and more as a managerial performance dimension subject to measurement, reporting, and optimization.

Other high-frequency trigrams deepen this interpretation. Sequences such as “environmental social governance” (1,088), “sustainability development goal” (1,061), and “supply chain management” (702) indicate that when broader environmental or global frameworks do appear, they tend to be operationalized within corporate governance and supply chain contexts rather than discussed on their own terms. The presence of “board gender diversity” (643) and “human resource management” (606) among the most frequent trigrams further illustrates how sustainability concerns are increasingly absorbed into organizational management discourse, stripped of their broader normative and political dimensions.

Qualitative framing analysis confirmed and extended these quantitative signals. Across abstracts, introductions, and conclusions, the dominant discursive logic positions sustainability as an instrument for risk mitigation and economic value creation. Terms like “financial performance” and “ESG performance” do not appear as mere neutral descriptors; they function as the evaluative criteria against which sustainability initiatives are measured. This framing forecloses, or at least marginalizes, alternative conceptualizations rooted in environmental ethics, climate justice, or planetary boundaries, none of which featured among the high-frequency terms. The relative absence of vocabulary associated with ecological limits, sufficiency, or redistributive justice is as informative as the presence of corporate and financial terminology.

Taken together, the quantitative and qualitative findings converge on the same conclusion: the dominant academic discourse on corporate sustainability is structured by a corporate-financial logic that subordinates ecological and social imperatives to organizational management objectives. This is not merely a semantic observation. Discourse shapes research agendas, policy recommendations, and educational curricula. When the field systematically frames sustainability as a means to financial ends rather than as an end in itself, it constrains the range of solutions that researchers conceptualize and the criteria by which those solutions are evaluated. For Environmental Education for Sustainability, this has direct consequences: students trained primarily within this hegemonic framing may develop sophisticated technical skills in ESG reporting or sustainability metrics while remaining largely unequipped to question the structural logics of growth, extraction, and capital accumulation within which those metrics are embedded.

It is important to note that these results do not suggest that corporate engagement with sustainability is inherently misguided, nor that the body of literature analyzed lacks scholarly merit. Rather, they highlight the value of critical discourse literacy as a complement to technical competence in sustainability education. Recognizing the assumptions built into dominant frameworks is a precondition for transcending them.

5. Conclusion

This study examines the academic discourse on corporate sustainability and its implications for Environmental Education for Sustainability (EEfS). By using a mixed-methods design combined with n-gram and qualitative framing analysis, this study identifies a consistent and structurally significant pattern. The study finds that the vocabulary in corporate sustainability literature is organized around a

corporate-financial logic. This logic is more relevant to organizational performance objectives than it is to ecological limits and ethical principles.

The n-gram analysis of a corpus of 604 Scopus-indexed articles included the frequency patterns of “corporate social responsibility," "financial performance," and "ESG performance." The frequency patterns reveal a disciplinary tendency to consider sustainability as a managerial variable. Furthermore, the qualitative framing analysis confirmed that this vocabulary is not neutral but is instead used as an instrument of risk management rather than for ecological and intergenerational justice. These findings highlight the need to foster critical discourse literacy as a core pedagogical outcome. Critical discourse literacy enables learners to operate within dominant frameworks while challenging the underlying values and assumptions through environmental ethics and climate justice.

Future research will incorporate a broader corpus beyond Scopus-indexed, English-language publications to examine whether the academic discourse on corporate-financial logic is applied uniformly or more predominantly in developed countries and how this discourse has changed over time. Locational research through a comparative study of academic discourse across regions including Latin America, the Global South, and East Asia may provide insights into local ecological vulnerabilities, governance, and cultural values. Such a locational study will provide local pedagogical implications and place-based frameworks for EEfS. A longitudinal analysis will compare discourse patterns across different decades. The ultimate goal is to close the gap between the principles of EEfS and the underlying assumptions of corporate sustainability through sustained efforts from researchers, educators, and policymakers.

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GENERATIVE AI AND THE DEEPENING OF UNDERSTANDING: A HUMAN-AI CO-THINKING MODEL FOR HIGHER EDUCATION

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Abstract

Generative AI (GenAI) is rapidly entering higher education, yet research often foregrounds risk (outsourcing cognition, plagiarism) or efficiency rather than how students use GenAI while learning. This qualitative study examines GenAI use in a liberal-arts course that paired in-class instruction with structured, out-of-class GenAI-supported reflection. After two sessions on the contemporary Kurdish question, 45 students submitted reaction papers describing how they consulted GenAI to deepen partial understanding, clarify confusion, and pursue self-generated questions without copying outputs. Inductive thematic analysis identified three recurrent functions: perspective structuring (mapping competing frames), causal clarification (probing sequences and interdependencies), and conceptual extraction (stabilising key terms before forming arguments). Reported learning gains depended on verification practices that compared AI responses with course materials and instructor cues. The paper proposes a Human–AI Co-Thinking Model that links these practices to scholarship on technology-supported education, instructor role transformation, and shifting norms of authorship, and it derives implications for instructional design, assessment, and accountable GenAI use.

Keywords: *Generative AI, deep understanding, higher education, human-AI collaboration, instructional design.*

1. Introduction

The rapid diffusion of generative artificial intelligence (GenAI) in higher education has blurred familiar lines between studying and producing, learning and composing, assistance and substitution. Institutional responses often polarise between risk and promise, but these debates can obscure a basic empirical question: when GenAI is integrated explicitly into a learning task, what do students actually do with it?

Liberal-arts learning aims at more than surface competence: students are expected to build structured understanding of unfamiliar conceptual systems and complex causal dynamics, then articulate a reasoned position. The contemporary Kurdish question provides a demanding case because it requires multi-perspectival reasoning across competing political narratives and historically layered causal claims.

This paper examines student reflections from a course design that combined online in-class engagement with structured, out-of-class GenAI consultation. Students were instructed to use GenAI not to generate substitutive answers but to deepen partial understanding, clarify confusion, and develop self-generated questions.

The paper's contribution is twofold: it offers an empirically grounded account of learning-oriented GenAI use in this instructional design and proposes a Human–AI Co-Thinking Model that connects these practices to scholarship on technology-supported education, changing instructor roles in GenAI environments, and shifting norms of authorship and originality (Gülbeyaz, 2014, 2026a, 2026b). It further outlines implications for instructional design and assessment in contexts where accountable GenAI use depends on making verification and transformation practices visible and non-optional.

2. Theoretical framing

2.1. Education as technology-supported by design

A useful starting point is to treat "technology-supported education" not as a recent add-on, but as a constitutive condition of organised education. Educational media do not merely provide new tools; they

reconfigure the organisation of learning itself, including roles, authority structures, and what counts as knowledge. From this historical lens, GenAI is legible as a further medium shift – continuous with earlier transformations from scribal practices to print and networked digital environments – yet with a distinctive feature: it competes not only with the teacher's tools, but with core functions involved in the production, structuring, and legitimation of knowledge. This intensifies the need to specify what instructors do – and should do – once a powerful para-instructor enters the learning ecology (Gülbeyaz, 2014, 2026b).

2.2. The instructor in a GenAI-equipped learning environment

Recent theorisation of teaching under GenAI conditions suggests a shift from a figure who monopolises answers to one who governs an ecology of inquiry. Rather than serving primarily as the producer and distributor of validated knowledge, the instructor's redesigned functions include: (i) curating relevance, (ii) moderating "error ecologies" (patterned ways misinformation, over-generalisation, and bias propagate within a learning environment), and (iii) establishing meta-rules – a "control grammar" – that make visibility, provenance, transformation, and cross-checking explicit.

This shift builds on a longer logic of distributing pedagogy across designed architectures. Classical intelligent tutoring systems, for example, already locate instruction in a modular system (e.g., student model, expert model, curriculum/diagnosis, and communication modules). GenAI effectively turns "communication" into an always-on, scalable, persuasive layer. In such conditions, the instructor's core job is less to supply answers than to engineer and enforce the conditions under which answers can legitimately count as knowledge (Wang et al., 2021; Gülbeyaz, 2026b).

The concept of control grammar is especially important where students can generate plausible text at scale. If GenAI makes production easier, then integrity cannot be reduced to prohibition; it becomes a design question. A control grammar can therefore require students to document prompts, describe how outputs were transformed, and demonstrate verification steps against course materials and other warranted sources. In this framing, the point is not surveillance but an explicit epistemic discipline: students learn the rules by which AI-supported work becomes academically accountable (Gülbeyaz, 2026b).

2.3. Authorship, originality, and the politics of intellectual ownership

A third strand concerns how GenAI destabilises inherited codes of authorship and ownership. Conventional academic regimes treat text as a traceable product of a single author, and originality as an individual property. Yet "intellectual ownership" is historically contingent, bound to modern ideas of individual authorship and originality that emerged comparatively late. Generative systems sharpen these tensions because machine-mediated production complicates how we attribute agency, labour, and credit.

In practice, this is experienced through at least three frictions: (i) GenAI produces text that is neither quotation nor transparent paraphrase; (ii) it makes "style" and "structure" replicable at low cost; and (iii) it encourages iterative co-production in which student agency is distributed across prompts, selections, and revisions. As a result, plagiarism policies that assume a binary opposition (original vs copied) become harder to apply, and the ethical focus shifts towards transformation and attribution: how students can responsibly rework AI-mediated material while making their own epistemic agency visible. The productive response is not to abandon integrity norms but to specify them in ways that match the new production ecology – so that academic ethics becomes something taught through design rather than inferred privately (Gülbeyaz, 2026a).

3. Research design

3.1. Course context and instructional design

Data were collected in a university liberal-arts course that combined online in-class instruction with structured, out-of-class reflection. The task positioned GenAI as a reflective partner in relation to instructor-provided materials (slides, short readings, and guiding questions). Students consulted GenAI in two designated ways: (i) to deepen partial understanding and (ii) to clarify points of confusion. Copying GenAI outputs into the reaction paper was explicitly prohibited.

3.2. Data and analysis

The dataset comprises 45 student reaction papers submitted after the two sessions. For analysis, submissions were reorganised into structured sheets that made (a) prompt content and (b) accompanying meta-reflections traceable during coding. These sheets were derived directly from the original submissions and preserved the distinction between the two task-specified prompt-types.

The corpus was analysed inductively through an iterative thematic analysis in four passes: (1) open coding of statements describing GenAI use; (2) axial grouping into broader functional clusters; (3) comparative validation across prompt-types and across cases; and (4) model building to link emergent

practices (as evidenced in students' written reflections) to the study's theoretical framing. The analysis foregrounds recurring functions and design-relevant mechanisms.

4. Findings: How students used GenAI to deepen understanding

In the "deepen" phase of the assignment, students used GenAI primarily to organise competing perspectives, elaborate causal accounts, and stabilise key concepts for subsequent argumentation. In this sense, conversational systems can support inquiry-oriented learning when used as dialogic resources rather than answer generators (Chan & Pawlina, 2020). Three recurring functions were identified: perspective structuring, causal clarification, and conceptual extraction.

4.1. Perspective structuring: Mapping competing frames

A prominent pattern was using GenAI to map or contrast competing perspectives in the Kurdish question. Students asked GenAI to summarise how different actors – states, ethnic groups, and international organisations – frame Kurdish autonomy in terms such as security threats, territorial integrity, or self-determination. In their reaction papers, students often reported that GenAI helped them "see the structure" of arguments rather than decide which argument is correct.

Perspective structuring refers to using GenAI to generate a provisional map of frames and then using that map to organise one's own reading of course materials. Students described that comparative summaries made it easier to locate the instructor's lecture points and understand why the same event can be interpreted differently by different parties.

A recurrent limitation noted by students was that GenAI sometimes "balanced" perspectives too neatly or produced generic summaries, which could flatten asymmetries in power, history, or normative stakes.

4.2. Causal clarification: Probing sequences and interdependencies

A second recurring pattern involved using GenAI to clarify causal sequences – what led to what, which actors reacted, and how decisions produced unintended consequences. For the Kurdish question, causal chains are historically layered, spanning imperial collapse, border settlements, state formation, repression–resistance cycles, regional wars, and shifting alliances.

Students used GenAI to ask questions such as: "What events intensified Kurdish nationalism?" "How did the Iraq War reshape Kurdish autonomy?" and "Why did certain regional governments shift policy?" In their accounts, this appeared as a move from "I heard about X" to "I can explain how X relates to Y." Causal clarification, in this sense, is the use of GenAI to elaborate linkages across dispersed facts into an interpretable narrative.

Many students described iterative querying (timelines → exceptions → disagreements → comparison with course materials), suggesting that deepened understanding depended less on any single response than on sustained questioning and cross-checking. This resembles self-regulated learning patterns that combine cognitive strategies (e.g., elaboration and organisation) with metacognitive control (e.g., goal setting and self-monitoring) (Pinkwart & Liu, 2020).

4.3. Conceptual extraction: Stabilising key terms before arguing

A third pattern involved using GenAI to extract and stabilise core concepts needed for analysis and argument. Students frequently reported uncertainty about terms such as nation, ethnicity, statelessness, sovereignty, self-determination, minority rights, and security dilemmas.

GenAI was used to obtain definitions, distinctions (e.g., "nation vs state"), and illustrative examples. Students then used these clarified concepts to re-read lecture points and craft their own claims. Conceptual extraction refers to this scaffolding move: establishing workable meanings that enable more coherent reasoning. Students also recognised that GenAI definitions could be overly broad or "textbook-like" and therefore required refinement to fit the course's risk-society framing.

Across all three functions, reported learning gains depended on verification and calibration practices. Students compared GenAI outputs with lecture slides, readings, and instructor cues; requested counter-arguments or alternative framings; and adjusted what they retained for relevance and specificity. Where GenAI use supported deeper understanding, they treated it as one voice among several and maintained agency through selection, revision, and triangulation rather than accepting outputs as final authority. The next section turns to the complementary "ask" use case: how students used GenAI to articulate and work through what they did not understand.

5. Findings: Asking what was not understood

The second major use case – explicitly required by the assignment – was asking GenAI about what students did not understand. In these accounts, GenAI functioned as a low-stakes, immediate tutor that reduced the friction of admitting confusion and enabled students to continue inquiry after class.

5.1. Question externalisation: Turning vague confusion into explicit questions

Many students initially described uncertainty in vague terms (e.g., "I don't get why …", "I'm not sure what this means …"). Through interaction with GenAI, these confusions were often reformulated into more explicit, tractable questions. For instance, a starting question such as "Why do Kurds not have a state?" could be refined into more targeted lines of inquiry (e.g., which treaties and state-formation processes impeded Kurdish statehood, or how international norms frame self-determination claims).

This process can be termed question externalisation: using GenAI to articulate and structure uncertainty. The educational value lies less in a final answer than in converting diffuse confusion into a set of workable inquiries that can be pursued through course materials.

5.2. Error exposure and correction: Discovering misconceptions

A further benefit reported by students was identifying and correcting misconceptions. Some accounts describe how GenAI exchanges made internal diversity visible (geographic, political, and linguistic), while others note that the interaction helped disentangle conflations across state contexts (Turkey, Iraq, Syria, and Iran).

At the same time, students' reflections indicate that GenAI can generate misconceptions as easily as it resolves them. In the more productive cases, students treated GenAI as one provisional source and calibrated it through the verification routines described in Section 4.3 (e.g., checking against slides, readings, and instructor cues).

5.3. Transition to personal positioning

For a liberal-arts reaction paper, the endpoint is not only comprehension but a reasoned stance. Many papers suggest a trajectory in which clarification of confusion supports subsequent organising moves (e.g., mapping perspectives and stabilising concepts) that enable students to articulate their own position. GenAI appears to support this transition when students maintain agency through selection, rejection, and reframing rather than adopting outputs as ready-made conclusions.

6. Discussion and implications

6.1. Re-reading "technology-supported education" under GenAI

Drawing on the usage patterns described in Sections 4–5, the findings support a media-historical reading of GenAI in higher education: when the dominant educational medium changes, the sites and authorities of explanation tend to shift with it. Students' reaction-paper traces suggest that GenAI created an additional dialogic space after class in which explanation, comparison, and questioning could continue. This is not simply "more study time" but a relocation of conceptual work – where students organise, test, and refine understanding beyond the classroom encounter (Gülbeyaz, 2014, 2026b).

6.2. The instructor as curator of relevance and moderator of error ecologies

In such an ecology, the instructor's role does not disappear but is redesigned: less a sole source of answers and more a curator of relevance and a moderator of "error ecologies". The implications of the present findings are practical: assignments and instruction can reward inquiry over extraction, teach routines of scepticism and triangulation, and treat recurrent GenAI tendencies (genericness, over-neat balancing, variable depth) as explicit objects of teaching rather than invisible failure (Gülbeyaz, 2026b).

6.3. From policing plagiarism to cultivating accountable transformation

When GenAI becomes part of learning, integrity hinges on disclosure and responsible transformation rather than on a simple used/did-not-use binary. This aligns with the view that conventional plagiarism norms rest on historically specific ideas of intellectual ownership that are increasingly destabilised by machine-mediated text production. A control-grammar approach reframes integrity as a design problem: tasks can require students to document prompts and key decision points, show how AI material was revised and integrated with course materials, and reflect on where GenAI helped and where it misled. This shifts evaluation towards verification and synthesis while making provenance visible (Gülbeyaz, 2026a, 2026b).

Taken together, the findings support a Human–AI co-thinking account: deepened understanding arose from students' active checking, rewriting, and integrating of AI outputs rather than from the outputs themselves. Related computational learning-theoretical work similarly frames AI as a partner that can accelerate inquiry, enable pauses, and support restarts, potentially expanding learners' agency and metacognitive control. Precisely because GenAI can also smooth over uncertainty and produce persuasive errors, the decisive condition is governance: co-thinking remains epistemically legitimate only when provenance, transformation, and verification are treated as non-optional routines rather than optional good practice (Gibson & Ifenthaler, 2024; Gülbeyaz, 2026b).

6.4. Practical design principles for GenAI-supported deep understanding

Three design principles follow from the model developed in this paper. First, separate "deepen" and "ask" phases so students explicitly work with what they partly understand as well as what remains unclear. Second, require a transformation trace: brief annotations of what was kept, rejected, and reframed (without demanding full chat logs). Third, teach verification as routine: triangulate claims with slides/readings, request counter-arguments or alternative framings, and independently check named facts. Together, these principles operationalise a broader shift – from treating GenAI as a forbidden shortcut to treating it as a site for practising responsible inquiry.

7. Conclusion and limitations

This paper shows how students used GenAI in a structured reflective design as a resource for deepening understanding rather than as a substitute answer generator. The central claim is that learning gains depended less on access to GenAI than on the practices and rules that shaped its use: students benefited when they retained agency through selection and revision and when course design made verification and transformation visible requirements. The Human–AI Co-Thinking Model captures this dynamic by treating GenAI as a dialogic partner in inquiry whose epistemic risks and affordances must be governed through explicit meta-rules.

This qualitative study is situated in one course context and relies on reaction-paper traces rather than full interaction logs, which limits fine-grained analysis of turn-by-turn dialogue and the timing of verification. Future work could triangulate self-reports with opt-in logs, classroom observation, and longitudinal designs that track how verification routines and transformation practices develop over time. For higher education, the practical task is not to choose between prohibition and uncritical adoption, but to redesign learning ecologies so that students learn to think with – and critically against – GenAI.

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SELF-DIRECTED LANGUAGE LEARNING TRAJECTORY: A CASE STUDY OF LANGUAGE LEARNER OF KOREAN AS A FOREIGN LANGUAGE

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Abstract

The rapid development of technology in recent decades has created digital generations who have grown up using high-tech devices as an inextricable part of their daily lives (Pedró, 2006). This generation often accesses second or foreign languages (L2) through freely available open sources from an early age, motivating their willingness to learn the target L2. As digital natives increasingly populate language classrooms, their presence has led to significant changes in L2 teaching and learning contexts. The present case study focuses on a non-heritage L2 Korean learner who self-studied Korean during his teens and was placed in the most advanced language course at a university in the U.S. The study aims to understand his self-directed learning approaches and the personal traits that propelled his language development, with the goal of deriving pedagogical implications for self-directed learners. The subject was interviewed in Korean for ten hours over one semester. Initially, he was exposed to the Korean language at age seven through his sister's interest in K-pop. Later, he developed a desire to learn Korean and began systematic study around age 14.5, utilizing online resources and vocabulary tools. His progress was facilitated by the remote learning environment during the COVID-19 pandemic. During this period, he was able to immerse himself fully in Korean, creating his own programs for language learning. Later stages included practicing through Korean media and attending university-level Korean classes. The interview revealed the digital generation's ability to use techniques in language learning, and the lack of institutional language classes did not hinder his learning motivation. Additionally, key personality traits, such as introversion and persistence, highlighted his focus on input and time management. His self-confidence and methodical approach to learning further underscored his autonomy. The findings suggest several pedagogical implications. First, learner autonomy is crucial for successful language acquisition, requiring motivation, effort, and self-awareness. Second, the self-use of techniques by the digital generation requires new approaches in language instruction. Finally, the subject's early exposure to Korean reveals the importance of community-wide language exposure activities. While the study's subject does not represent all digital natives, his experience illustrates the potential benefits of a paradigm shift in language classroom, including re-designing language courses with more individualized sessions in higher education to better serve the needs of digital generations.

Keywords: *L2 learning, self-directed learning, learner autonomy, digital generation, learner traits.*

1. Introduction

The rapid development of technologies in recent decades has led to an emergence of digital generations who have been raised with digital technologies as an inextricable part of daily life (Pedró, 2006). These generations are often called "digital natives" (Prensky, 2012), "the net generation" (Tapscott, 1998), or Gen Z in recent years. The behaviors of these generations in second or foreign language (L2) learning are different from traditional ways of learning due to the changed environments. Most notably, learners can easily access cultural contents using foreign languages, thanks to freely available resources through domestic and international service platforms (e.g., YouTube, Netflix). This accessibility has enabled learners to be exposed to foreign language of their own interest from an early age. This shift has changed the environment in language classrooms in higher education settings, filling them with more learners who have prior knowledge of the target language. While language instructors acknowledge these learners' previous exposure and place them in appropriate proficiency-level classes, little attention has been given to their learning paths. Considering the changing dynamics of traditional classrooms, retracing the path of self-taught students is worthwhile to investigate for pedagogical implications for self-directed learners. Thus, this study aims to follow the trajectory of one subject's Korean learning as a foreign language, who self-taught Korean in his teens and was placed in the most advanced proficiency level course at the university. While the subject does not represent the entire generation, this case study is expected to provide pedagogical implications for language classes with more self-directed learners.

2. Literature review

The concept of self-directed learning is characterized by learners' autonomy and initiative in their educational pursuits. Benson (2011) suggests that a key aspect of self-directed learning is learners' ability to take charge of their own learning process, including planning, monitoring, and evaluating their understanding. Several studies investigate multifaceted aspects of self-directed learning. To illustrate, Dabbagh and Kitsantas (2012) acknowledge the integration of social media technologies has significantly supported self-directed learning by providing tools to create personal learning environments. Similarly, Al Ghazali (2020) argues that learning philosophy needs to be modified to integrate self-access learning that utilizes online and digital resources to enhance learner autonomy, particularly in response to changes in the learning environment during and after the COVID-19 pandemic. Broadly speaking, autonomous learners have the authority to control their own language-learning methods and tools in accordance with their learning goals.

The role of motivation in learning L2 has been discussed widely. Schmidt (1992) underscores the importance of psychological mechanism, such as motivation and anxiety, in L2 acquisition. Sansone and Smith (2000) also argue that individuals self-regulate their motivation when completing tasks and that interest-enhancing strategies are effective. More importantly, Deci and Ryan (2000) posit that intrinsic motivation driven by personal interest and enjoyment is crucial for effective self-directed learning. Relatedly, Schiefele (2001) summarizes several studies on the role of interest in learning and concludes that topic interest significantly contributes to the text learning even when individual differences such as previous knowledge are considered. More recently, Alamer et al. (2025) conducted a meta-analysis using data from 21 primary studies and found out that autonomous motivation that includes intrinsic and identified regulation significantly correlates with language achievement.

Ultimately, self-directed learning is a multifaceted process that relies on learners' autonomy and the effective use of resources while being fundamentally driven by learners' motivation and interest. As the learning environment continues to evolve, particularly with the integration of technologies, discussions on how to implement self-directed learning in higher education become increasingly essential.

3. Methods

The present study adopts a case study to understand a longitudinal and holistic exploration of a complex phenomenon (Stake, 1995). The subject of the present study visited the Korean program at a university in the U.S. to take a language placement test. His name was Keith, a pseudonym of his own choice. He was an English native speaker and a 20-year-old majoring in Computer Science. He was about to enter his senior year and wanted to take Korean courses before graduation. The placement test in the program consisted of answering multiple choice questions after reading, semi-formal oral questions, and writing. His test results showed his ability to take the highest proficiency level course. It should be noted that the purpose of the placement test is not to obtain any standardized proficiency score but rather to find the most appropriate class for the participant among the courses offered in the institution, considering the participant's holistic language skills. The university offered one grammar course per semester from Year 1 through Year 4, totaling eight courses, in addition to two content-based advanced courses taught over two semesters in Year 5. The advanced courses deal with various social issues and focus on advanced language skills such as oral discussion on social issues and writing argumentative essays. Keith was placed in the advanced level course. Since his placement in the most advanced class is not a popular path for non-heritage learners who haven't taken any Korean classes, it was worth understanding his learning trajectory. He gladly agreed to participate in the study and to share his experiences. We had regular meetings for about one hour per week for ten weeks. Various topics were covered including both his language learning process and his personal traits, such as strengths, weaknesses, plans, and hobbies. All the conversations were conducted in Korean, per his preference, and there was no time limit for answering the questions.

4. Findings

4.1. Self-directed learning progress

4.1.1. Initial exposure. Keith's first experience with Korean was through his sister when he was seven. His sister, who was seven years older than him, was a fan of K-pop songs. She taught him a few idiomatic expressions such as *annyenghaseiyo* 'hello' and *ce-nun Keith-yeyyo* 'I am Keith', as well as a few easy words like *aisukhulim* 'ice cream', an English borrowed word. He also gradually practiced *Hangul*, the Korean alphabet, incrementally. Even though he did not consciously focus on learning, he was exposed to the language over time without realizing it.

4.1.2. Foundational scaffolding and intensive vocabulary acquisition. When he was about 14.5 years old, he decided to 'study' Korean in a more structured manner. He believed that learning grammatical structures was critical, so he watched free instructional video clips that taught Korean grammatical patterns through platforms like YouTube. At this stage, he would turn on Korean podcasts to create an immersion environment while resting. He began keeping a diary in Korean after about six months of learning.

After one year of pattern practice, Keith moved on to vocabulary learning. It was during his summer vacation, so he spent all his time memorizing Korean new words. He selected new words from K-pop lyrics or comments left by Korean users on cultural content, such as chat boxes in online games, news, and entertainment shows. Often, he would read comments without watching the clips or playing the games. He used digital platforms that allowed him to create his own Korean-English (K-E) flashcards as a tool to memorize vocabulary. He remembered that there were always thousands of new words to memorize. When the vacation was over, he could allocate about two hours per day for Korean. He used one hour for reading comments and choosing words, and the other hour for memorizing the words. This period lasted about one year.

4.1.3. Monolingual learning. When he was 16.5 years old, his school switched to remote learning due to the COVID-19 pandemic. He frankly enjoyed this mode as he could manage his own time for schoolwork and Korean learning. By this time, after one year of grammar practice and one year of vocabulary training, he observed himself progressing to a different stage. He had little difficulty reading comments and realized that he had made significant improvements. For about six months until the school returned to in-person learning, he made Korean-Korean (K-K) flashcards, writing his own definitions of words. For instance, to memorize *kananhata* 'to be poor', he wrote *ton-i epsese sanyhal-i elyepta* in Korean which means '(someone's) living is hard because the person doesn't have money' instead of using the English translation 'to be poor'. This way, he could connect previously known words such as 'money' and 'to not have' with *kananhata* and associate the target words with other commonly related words. For this practice, he used space repetition systems (SRS). SRS is an online system that shows the cards the users made at pre-set intervals. For example, if a learner creates a card, the system will show it randomly in 2 days, then in 8 days, and again in three weeks, etc. The system included pre-made K-E decks, but Keith created his own decks to understand Korean words through Korean explanations and to connect with related words. He often inserted related pictures into his own decks.

4.1.4. Consolidation through authentic affinity spaces. He was 17 years old when he went back to school. At this time, he could not spend as much time practicing Korean as before because he had to prepare for college entrance exams. Despite not 'studying Korean hard', he continued to engage with the language through authentic affinity spaces. He played online games with the language mode set to Korean without English subtitles and watched Korean news or entertainment shows. Additionally, he began to read more advanced passages written in Korean. He searched *Namwu-wiki*, the Korean version of Wikipedia, for topics that interested him, such as mushrooms, and read the explanations there. He looked up some new words in these passages and created his own decks, but he recalled that he did not have much difficulty reading them and could easily connect the new words with other words he knew. After entering college, he continued this practice for three years. One change was that he started using a new SRS system, which was much user-friendly than the previous one, and he would write whole sentences in his deck when he encountered new words.

4.2. Motivation

In addition to language learning, the conversations covered Keith's personality. The most salient strength of Keith was his determination towards his interest. According to him, once he got into something, he could not stop until he fully understood the subject. He used to spend hours acquiring knowledge about topic of his own choice. As he was not a competitive person, he did it not to outdo others but purely for self-satisfaction. He described himself as introverted and having a high level of academic curiosity. He did not enjoy physical outdoor activities; instead, he preferred staying indoors, learning, practicing, and repeating the knowledge he acquired. Regarding his Korean learning, he identified "input" and "immersion" as the major factors influencing his learning. That is, after the initial stage when he studied Korean grammatical patterns in English, he emerged himself in Korean language environment by listening to and reading authentic Korean materials, making K-K vocabulary cards, and writing journals in Korean. Overall, it seems that Korean language became his primary interest, and he delved into it until he was satisfied, placing himself in an immersive environment.

5. Discussion

5.1. Personality and learner autonomy

The findings suggest that the subject's personality plays a significant role in the development of Korean language proficiency. His self-description as non-competitive and driven by self-satisfaction highlights the importance of intrinsic motivation. In addition, Keith's strong academic curiosity and introverted disposition encouraged sustained progress toward the goals he set, contributing to a highly focused learning style. His intrinsic motivation and enjoyment of learning further illustrate how personal interests can facilitate meaningful language acquisition (Deci and Ryan, 2000).

Notably, he independently structured his learning pathways, monitored his progress, and adapted his study methods appropriately (e.g., shifting from K-E to K-K cards) without formal guidance. Through this process, he developed effective learning strategies and learned how to learn. His learning trajectory exemplifies learners' capacity to self-manage their learning by adjusting strategies over time and demonstrates how autonomous learners can achieve their goals independently.

5.2. The power of digital affinity

The emergence of technology has expanded opportunities for autonomous learning behaviors. The use of freely available resources, such as YouTube and Korean-language podcasts, suggests the importance of accessible tools and platforms in self-directed learning. Learners of digital generation, who are accustomed to navigating online resources, can benefit substantially from these technological developments, as they enable exposure to an immersive language learning environment through a vast range of authentic materials. This shift can enhance learner motivation and foster a sense of belonging that is often difficult to achieve through traditional instructional materials, as illustrated in Keith's case. Although he lived in a community where the target language was not commonly used, he was able to encounter authentic language use through online affinity spaces that offered contextualized and practical engagement with the language. These spaces helped create a rich and immersive learning environment, allowing him to develop a sense of connection to Korean society.

5.3. Re-evaluating instructors' role and community connection

The presence of learners with previous knowledge of the target language as non-heritage language users has changed the environment of language classrooms in higher educational institutions. When instructing learners who have followed the institution's curriculum, instructors know what their students know and what they don't. However, when learners come to class with previous knowledge of the language, instructors must address their language skills (e.g., speaking, vocabulary) and understand their goals. In this regard, the role of instructors as guides is more important than ever. Keith had meetings with one of the Korean program instructors during her office hours for about two hours per week for one semester. During the interview for this study, he reiterated several times that these office-hour meetings were far more productive and meaningful for him than classroom sessions. This implies that allocating more in-person sessions and providing individualized feedback and appropriate resources for each student may better serve students' needs. Considering the practical limitations in each institution, such as limited number of faculty members and classrooms, redesigning current language courses to include more independent sessions will be helpful.

Additionally, establishing a network with the community will become a critical responsibility of language programs of higher educational institutions. Keith was fortunate to have a sister who was interested in the Korean language and culture. This early exposure to Korean significantly impacted his motivation and learning. As seen in his case, digital generations may be more accustomed to finding their own ways of experiencing foreign language and cultures through the consumption of cultural content. Providing more opportunities for young people to be exposed to the target language and culture during K-12 school days or through extracurricular activities will help foster a population interested in the target language. This connection between higher education and the community will ultimately achieve the goals of language education, which are to equip students with language skills for life tasks and to fulfill learners' needs.

6. Conclusion

The present study is a case study; Keith does not represent the entire net generation or all self-taught learners. Some factors that influenced his learning, such as the degree of his determination and having a sister who were interested in Korean, are unique. Thus, the findings are not generalizable but rather illustrative. However, his case reveals that digital generations have easy access to foreign language contents these days and they utilize available sources as they wish. The environmental changes in learning L2, including free resources and useful platforms, and learners' way of using them need to be acknowledged to design curricula that guide each learner to their own goals and set up learner-oriented classrooms for

digital-friendly generation. Follow-up studies on comparative cases of learners with different personality types, integrating affinity spaces into a curriculum, and training instructors to be effective mentors for autonomous learners will invite richer discussions.

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GENERATIVE ARTIFICIAL INTELLIGENCE AS A TOOL FOR INFORMATION MANAGEMENT IN HIGHER EDUCATION: AN EMPIRICAL STUDY ON STUDENT PRACTICES AND PERCEPTIONS

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Abstract

Generative Artificial Intelligence (GenAI) technologies, such as ChatGPT, are playing an increasingly prominent role in higher education, particularly in supporting students' engagement with academic information. These tools offer new possibilities for searching, structuring, synthesizing, and understanding complex materials, often altering traditional strategies of studying, note-taking, and preparing assignments. At the same time, their growing use raises concerns related to informational reliability, superficial learning, and the need for new forms of academic guidance. This study investigates how undergraduate students—predominantly enrolled in business, economics, and management-related programs—interact with GenAI tools as part of their information management practices. It explores the purposes for which these technologies are employed, students' perceptions of their usefulness and limitations, as well as their attitudes toward the ethical and educational implications of AI integration in academic work. Empirical data were collected through an online cross-sectional survey conducted in 2025, focusing on frequency of use, main academic applications, perceived benefits and risks, and expectations toward university policy and support. The findings show that GenAI use is widespread and frequent: all respondents reported using such tools at least occasionally, with 45.7% using them daily or almost daily and 20.0% on a weekly basis. Students most commonly used GenAI for searching for information, summarizing and organizing academic content, solving problems, paraphrasing or improving language, and generating ideas for assignments, while using AI to write parts of academic work was relatively uncommon. Students strongly emphasized the usefulness of GenAI for information management and learning efficiency, yet simultaneously expressed high levels of caution regarding reliability, stressing the need to verify AI-generated information and the risk of false or misleading outputs. The findings contribute to ongoing discussions on the responsible use of AI in higher education by highlighting students' evolving roles as both intensive users and critical evaluators of generative technologies. The results point to a consistent pattern of high utility combined with high caution, in which students value GenAI as an information-management tool while calling for clearer institutional norms, ethical guidelines, and targeted support. These findings are intended to inform the future development of academic policies, digital literacy training, and pedagogical frameworks that promote critical, ethical, and effective use of AI in higher education.

***Keywords**: Generative AI, higher education, information management, student perceptions, digital literacy.*

1. Introduction

The rapid rise of Generative Artificial Intelligence (GenAI) tools has intensified debate about their impact on higher education. Global evidence suggests that student adoption is widespread and growing; for example, the Digital Education Council's (DEC) global AI student survey reports large-scale student uptake and highlights information-related use cases such as searching and learning support (Digital Education Council [DEC], 2024). Large-scale international research also indicates that students often use GenAI for learning-related tasks such as brainstorming, text summarization, and searching for research materials (Ravšelj et al., 2025).

In this paper, information management is defined as student practices used to (a) obtain academic information (e.g., explanations, concepts, sources), (b) transform it for learning (e.g., summarizing, paraphrasing, structuring), (c) organize and retrieve it (e.g., notes and study materials), and (d) evaluate credibility and fitness-for-purpose (including verification and cross-checking). This operationalization aligns with broader personal information management perspectives that emphasize acquiring/creating, organizing, maintaining, retrieving, and using information to meet task goals (Jones, 2007).

In academic practice, GenAI tools introduce new possibilities for information management: rapid explanations, automated summarization, idea generation, and language refinement. However, the educational value of these affordances depends on how students use them and how reliably the tools behave. A key concern is that language models may produce fluent but incorrect statements ("hallucinations"), which makes verification skills central to safe academic use (Huang et al., 2023). OpenAI's analysis similarly frames hallucinations as a persistent reliability challenge that can appear even for seemingly straightforward questions and argues that evaluation and training incentives can reward guessing over calibrated uncertainty (OpenAI, 2025). Prior research has also documented the fabrication of bibliographic citations in model-generated text, which is directly relevant to students' literature searching and referencing practices (Walters & Wilder, 2023).

Given these opportunities and risks, universities face a policy and pedagogy challenge: how to leverage GenAI to support students' information management and learning without undermining academic standards and deep learning. International guidance emphasizes the importance of human-centered and ethical integration of GenAI, including capacity building and clearer governance (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2023). Empirical research that focuses on student practices and perceptions is therefore needed to inform institutional guidelines and AI literacy efforts. Studies in different contexts (e.g., Hong Kong or multi-university samples in Italy) generally report positive student attitudes accompanied by concerns around accuracy, ethics, and personal development (Chan & Hu, 2023; Farinosi & Melchior, 2025).

Against this backdrop, the present study provides empirical evidence from an online survey of undergraduate students (mostly in business/economics/management-related fields) about (a) how frequently and for what purposes they use GenAI, (b) what benefits and risks they perceive, and (c) what institutional responses they prefer.

2. Objectives of the study

The primary goal of this study is to investigate the use of generative AI as a tool for information management among higher education students, using a cross-sectional survey design. The specific objectives are to:

1. Assess usage practices, including frequency and main academic tasks supported by GenAI (e.g., searching for information, summarizing content, organizing study materials).
2. Evaluate perceptions of benefits (e.g., efficiency and understanding) and perceived risks (e.g., the need to verify AI outputs, concerns about superficial learning and intellectual independence).
3. Understand student attitudes toward institutional policy and support, including preferences for governance (ban vs. guidelines vs. integration) and the need for training.

3. Methodology

3.1. Research design, sample, and data collection

This study employed a cross-sectional online survey to gather quantitative data on students' experiences with generative AI tools in academic contexts. The survey was administered in 2025. Participation was voluntary, responses were anonymous, and no direct personal identifiers were collected.

A total of N = 35 responses were included in the analysis. The sample was balanced by gender (48.6% female; 51.4% male). Most respondents were in the 18–25 age range (54.3% aged 18–21; 42.9% aged 22–25; 2.9% above 30). All respondents reported a first-cycle level of study (Bachelor's/Engineering). The field of study was highly concentrated: 97.1% of respondents reported a business, economics, and management-related field, with 2.9% reporting an interdisciplinary/other field. This concentration implies that findings should be interpreted as evidence about this particular student group rather than as fully cross-disciplinary conclusions.

3.2 Survey instrument

The instrument was a structured questionnaire comprising: (a) background information, (b) AI usage patterns, (c) perceptions of usefulness and risks (Likert-type statements), and (d) attitudes toward university policy and support. It included demographic items (gender, age group, study level, study field), items on familiarity with GenAI tools, frequency of use, checklist-based questions on purposes of use (multi-select), a question on the typical stage of academic work when AI is used, a set of Likert statements (1–5) capturing perceived benefits and risks, and final items about preferred university policy and training needs. An optional open-ended question captured additional comments.

Analysis was descriptive. Frequencies and percentages were computed for categorical variables. For Likert items, means and standard deviations were computed and agreement was operationalized as

responses 4–5. To characterize the coherence of perceived-benefit items, internal consistency was estimated for a three-item benefit subscale (acquire/organize information; understand faster; improve effectiveness), yielding Cronbach's alpha = 0.88.

4. Results

4.1. AI usage patterns among students

All respondents reported using generative AI tools in their studies at least occasionally. Nearly half (45.7%) reported daily or almost daily use, 20.0% weekly use, 25.7% use a few times per month, and 8.6% occasional use (a few times per semester). Thus, 65.7% used GenAI at least weekly, indicating that these tools are embedded in routine academic practices for a majority of the sample.

The most prevalent self-reported application was searching for information (71.4%), followed by solving problems (e.g., math, coding) (54.3%), summarizing content (51.4%), organizing notes or content (51.4%), generating ideas for projects/assignments (48.6%), and paraphrasing or language improvement (48.6%). Using AI to write parts of academic work was reported by 11.4%. In terms of workflow timing, 51.4% reported using AI most often at the beginning of academic work (understanding the topic and planning), 22.9% during content development, and 25.7% at the end (editing/proofreading).

Because the sample is dominated by one study field and one study level, demographic comparisons are presented descriptively only; the dataset does not support strong inferences about disciplinary differences.

4.2. Perceived benefits of GenAI for learning

Students' perceptions were largely positive regarding informational and learning efficiency. A large majority agreed that AI helps them acquire and organize information (85.7%; M = 4.06, SD = 0.87) and that AI improves the effectiveness of their learning and work (88.6%; M = 4.09, SD = 0.95). Similarly, 85.7% agreed that AI enables them to understand difficult academic content more quickly (M = 4.26, SD = 1.04). These responses suggest that students experience GenAI primarily as an efficiency and comprehension aid—especially in early-stage information gathering and sense-making.

At the same time, only a minority agreed that they rely on AI more than traditional sources such as textbooks and lectures (28.6%; M = 2.89, SD = 1.25), indicating that, in this sample, GenAI tends to complement rather than fully displace established learning resources.

4.3. Challenges and concerns

The dominant concern was informational reliability. Almost all respondents agreed that information provided by AI requires verification (94.3%; M = 4.69, SD = 0.58) and that AI can generate false or misleading content (94.3%; M = 4.57, SD = 0.70). A substantial majority also expressed concerns that AI may limit intellectual independence (74.3%; M = 3.89, SD = 1.21). About half agreed that AI may lead to superficial learning (51.4%; M = 3.57, SD = 0.70), suggesting uncertainty and potential heterogeneity in perceived long-term learning effects.

Open-ended comments (n = 19 responded; n = 13 substantive) reinforced these issues. Recurring themes included: a strong emphasis on critical use and cross-checking; reports that AI outputs may repeatedly reproduce the same misconceptions even after "corrections"; and concerns that AI detectors may incorrectly classify original student work as AI-generated, creating anxiety about fair assessment.

4.4. Attitudes toward integration and policy

Students overwhelmingly supported a governance-oriented approach rather than prohibition. Most respondents preferred allowing AI use under clear rules and ethics (57.1%), while 22.9% favored encouraging AI use and integrating it into teaching. Another 14.3% preferred conditional permission depending on instructor guidelines, and 5.7% had no opinion. No respondent supported a complete ban.

A majority (62.9%) wanted the university to offer training or support in using AI. Self-confidence was also high: 85.7% reported feeling confident in their ability to use AI-based tools in a responsible, ethical, and informed manner. This combination suggests that students value institutional support not only to build basic competence, but also to clarify norms, expectations, and boundaries of acceptable use.

5. Discussion

This study provides empirical evidence that undergraduate students in a business, economics and management-focused sample use GenAI intensively for information management. The most common uses—information searching, summarizing, organizing notes, paraphrasing, and ideation—map directly onto an information-management workflow (Jones, 2007). The observed pattern aligns with international

evidence that students frequently use GenAI for searching, summarizing, and finding research materials (DEC, 2024; Ravšelj et al., 2025). Log-based research also indicates that student interactions with ChatGPT often cluster around information seeking, content generation, and refinement behaviors, supporting the interpretation that GenAI becomes integrated into self-directed learning routines (Ammari et al., 2025).

A key contribution of the present findings is the consistency of the "high utility–high caution" profile. Students strongly endorse informational benefits (efficiency and faster comprehension) while simultaneously emphasizing verification and acknowledging the risk of misleading content. This stance is well grounded in the known behavior of large language models: hallucinations remain a recognized failure mode and can occur even in simple informational queries (Huang et al., 2023; OpenAI, 2025). Importantly, in academic contexts reliability concerns extend beyond factual claims to the scholarly infrastructure of citations and sources; the documented frequency of fabricated references in ChatGPT-generated text makes students' verification stance educationally rational (Walters & Wilder, 2023).

From a pedagogical and institutional perspective, the survey suggests four implications that respond directly to reviewer requests for more concrete "teaching-related" contributions. First, institutions should move from inconsistent, instructor-by-instructor approaches toward coherent guidance (policy statements, syllabus-level rules, and examples of acceptable and unacceptable GenAI uses). The strong student preference for guidelines over bans mirrors patterns found in other contexts, including the Italian multi-university study, where regulation was generally preferred over prohibition (Farinosi & Melchior, 2025), and aligns with UNESCO's guidance emphasizing governance and human capacity development (UNESCO, 2023).

Second, universities should frame verification as a core AI literacy outcome: students already endorse verification in principle, so training can emphasize practical routines—cross-checking claims with primary sources, validating bibliographic references, identifying uncertainty boundaries, and documenting verification steps. Third, educators can design assessments that treat GenAI as a scaffold rather than a shortcut: because students report most frequent use at the beginning of tasks (topic understanding and planning), assignments can explicitly allow ideation and outlining while requiring a transparent account of prompts, verification activities, and reflective critique of AI outputs. Fourth, qualitative concerns about AI detectors highlight an assessment-risk issue: overreliance on uncertain detection may create false positives and undermine trust. A more robust integrity strategy is process-based evaluation (drafts, oral defense, iterative feedback, and transparent citation of AI assistance) complemented by clearly communicated norms.

Several limitations require emphasis. The sample is small (N = 35), non-probabilistic, and highly concentrated in one field and study level; therefore, the findings should be interpreted as a focused case and not generalized to all students or disciplines. The study also relies on self-report; future research would benefit from mixed methods (interviews, diaries, or usage logs), broader sampling across disciplines and institutions, and explicit measurement of academic integrity and privacy concerns.

6. Conclusions

The survey results indicate that GenAI is already a routine element of information management among surveyed undergraduate students in a business, economics and management-focused sample. Students report frequent use, especially for information searching, problem solving, summarization, organizing study materials, and language refinement. They simultaneously demonstrate strong awareness of reliability risks and the need to verify AI outputs. Most students prefer institutional policies that allow AI use under clear ethical rules and express a strong demand for training/support, even when they feel individually confident.

Overall, the findings support a balanced path forward: higher education institutions should treat GenAI as a permanent component of the learning environment while investing in clear guidance and AI literacy practices that strengthen verification, critical evaluation, and responsible use.

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INTERNATIONALIZATION AND TEACHING INNOVATION IN HIGHER EDUCATION THROUGH AN ERASMUS+ INITIATIVE

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Abstract

This paper examines the outcomes of an Erasmus+ KA220-HED cooperation partnership that fostered teaching innovation and international collaboration in higher education through active learning and service-learning methodologies. A key component of the initiative was a transnational service-learning experience conducted in Morelia, Mexico, where 20 students and 16 faculty and staff members from all partner institutions collaborated with local communities on educational, health, and sustainability projects. Quantitative and qualitative data were collected through the *Service-Learning Experience Benefit (SELEB)* questionnaire to assess perceived learning outcomes. Results showed significant improvements in students' transversal competences, intercultural understanding, and social responsibility. The findings suggest that transnational service-learning provides an effective framework for integrating internationalization and teaching innovation, supporting both professional development and student engagement. The project demonstrates how Erasmus+ cooperation partnerships can act as catalysts for pedagogical transformation, linking local action with global educational goals and contributing to the creation of inclusive, sustainable, and globally connected higher education systems.

Keywords: *Higher education, Erasmus+, teaching innovation, internationalization, active learning.*

1. Introduction

The growing interconnection between global education systems and the need for innovative teaching practices have placed internationalization at the center of higher education policy and reform. European universities increasingly recognize that the ability to engage students and teachers in international, intercultural, and interdisciplinary collaboration is not only a goal but also a catalyst for educational transformation (Fumasoli & Rossi, 2021).

Within this landscape, the Erasmus+ Programme, and specifically the KA220-HED Cooperation Partnerships, have become critical mechanisms for promoting innovation and inclusivity across national borders. These partnerships enable universities and social organizations to jointly develop and implement innovative educational practices that link academic learning with real-world challenges (Grynova & Kohut, 2022).

The project examined in this study, which is part of the Erasmus+ "Generation for Innovation, Resilience, Leadership and Sustainability (GIRLS)" initiative, brought together higher education institutions, research centers, and civil society organizations from Europe and Latin America. Its objective was to foster teaching innovation, enhance transnational collaboration, and integrate the principles of service-learning (SL) and active learning (AL) into university curricula.

A key milestone of the project was the service-learning experience conducted in Morelia, Mexico. During this short-term mobility, mixed teams of European and Mexican students collaborated with local community partners on projects addressing health awareness, environmental sustainability, and educational inclusion. This experience allowed participants to apply academic knowledge in real contexts, promoting empathy, teamwork, and intercultural dialogue.

The present paper examines both the perceived benefits among student participants, measured through the SELEB questionnaire, and the institutional outcomes, assessed through project indicators

collected from partner organizations. Together, these data provide a comprehensive understanding of how international cooperation through Erasmus+ can drive innovation in higher education by connecting teaching, research, and societal engagement.

2. Literature review

The Erasmus+ program has evolved from a mobility scheme into a comprehensive policy tool for fostering educational innovation, inclusion, and cross-border collaboration in higher education. Its KA2 Cooperation Partnerships (such as KA220-HED) encourage universities, research centers, and NGOs to develop and test new pedagogical models that link academic learning to real societal needs (Fumasoli & Rossi, 2021).

Participation in Erasmus+ initiatives has proven to strengthen institutional internationalization strategies, encouraging European Higher Education Institutions (HEIs) to engage in joint research, digital innovation, and inclusive curricula design (Grynova & Kohut, 2022; Ishchenko, 2025). Moreover, Ovtšarenko et al. (2024) demonstrate that blended and short-term mobility projects (e.g., BIPs) democratize access to international experiences, supporting the European Education Area's commitment to quality, equity, and sustainability.

The GIRLS Erasmus+ project exemplifies this synergy between international cooperation and pedagogical innovation, particularly by connecting European and Latin American partners in a shared framework of experiential learning and service to society.

Service-learning has become one of the most widely recognized methodologies for linking academic instruction with social engagement. Through community-based activities, students apply disciplinary knowledge to address authentic social challenges while developing critical thinking, empathy, and leadership (Mierlus Mazilu et al., 2025).

A systematic review by Queiruga-Dios et al. (2021) identifies SL as a key pedagogical tool in engineering education, fostering the integration of technical knowledge with civic responsibility and sustainability awareness. This evidence aligns with the findings of Rasteiro et al. (2024), who emphasize that service-learning "bridges academic learning and community service" by promoting interdisciplinary cooperation and active participation across European and Latin American educational contexts.

Similarly, Hernández Encinas et al. (2025) highlight in service-learning: A Bridge Between Academic Knowledge and Social Engagement that Erasmus+ frameworks, such as the GIRLS Project, enable the institutionalization of SL across multiple disciplines, creating sustainable educational practices that combine teaching, research, and social transformation. In the same proceedings, Mierlus Mazilu et al. (2025) describe how the UTCB successfully integrated SL into engineering education, using community projects to develop students' problem-solving and innovation competences.

In the context of the current Erasmus+ initiative, service-learning not only provided a vehicle for active learning but also acted as a cultural bridge, connecting European pedagogical innovation with Mexican community realities. International cooperation in education contributes significantly to students' intercultural competence, understood as the ability to communicate and collaborate effectively across cultural and linguistic boundaries (Queiruga-Dios et al., 2023).

In the GIRLS project, intercultural collaboration was achieved through joint teaching teams and mixed student groups working in transnational service-learning activities. The mobility to Mexico provided an immersive context for participants to experience diversity and co-create knowledge with local communities. This approach is consistent with the innovation pedagogy model (Keinänen & Kairisto-Mertanen, 2019), which integrates creativity, reflection, and collaboration as key elements of transformative learning.

Institutional engagement is essential for ensuring the sustainability of teaching innovation. Fumasoli and Rossi (2021) emphasize that universities participating in Erasmus+ networks serve as engines of educational transformation but require policy alignment and organizational support to mainstream innovative practices. In this regard, the GIRLS partnership exemplifies the quadruple helix model of innovation in education, where academia, civil society, and research institutions co-create pedagogical solutions. The inclusion of partners such as AELCLÉS and the Maristas Champagnat School expands the impact of innovation beyond universities, connecting the project's academic outputs with societal needs in health education, inclusion, and community engagement.

Moreover, the collaboration between the University of Salamanca, the Francisco de Vitoria University, the Polytechnic University of Coimbra, and the Technical University of Civil Engineering of Bucharest demonstrates how cross-national cooperation can lead to institutional learning, digital transformation, and strengthened academic networks. These results echo the findings of Hernández Encinas et al. (2025) and Mierlus Mazilu et al. (2025), confirming that innovation and internationalization are mutually reinforcing processes that can be effectively advanced through Erasmus+ strategic partnerships.

3. Methodology

3.1. Research design

This study adopts a mixed-methods approach, integrating quantitative and qualitative data to examine the impact of the Erasmus+ cooperation partnership on teaching innovation and internationalization. Quantitative and qualitative data were gathered from the Service-Learning Experience Benefit (SELEB) questionnaire, completed by students after their participation in the service-learning activity in Mexico.

3.2. Participants

The partnership involved eight organizations:

1. University of Salamanca (Spain)
2. Polytechnic Institute of Coimbra (Portugal)
3. Francisco de Vitoria University / Accompaniment Institute (Spain)
4. Technical University of Civil Engineering of Bucharest (Romania)
5. Spanish National Research Council (CSIC)
6. Spanish Association of Entities against Leukemia and Blood Diseases (AELCLÉS)
7. Marist Champagnat School (Spain)
8. Vasco de Quiroga University A.C. (Mexico)

A total of 20 students (four from each university) and 16 faculty/staff members (two per partner institution) participated in the service-learning mobility to Mexico.

3.3. Instruments

The SELEB questionnaire (post-activity version) assesses perceived benefits of service-learning experiences across several dimensions, including personal growth, teamwork, leadership, communication, cultural understanding, and civic responsibility. Items are rated on a 7-point Likert scale.

3.4. Procedure

Students participated in collaborative service-learning projects in Morelia, Mexico, supported by local community organizations. Activities included educational workshops, health awareness campaigns, and creative projects addressing social challenges. Following the mobility, participants completed the SELEB questionnaire online.

Data were analyzed using descriptive and inferential statistics for quantitative items and thematic coding for qualitative responses.

4. Results

Overall, student responses indicate very high levels of perceived benefit across all SELEB dimensions (all means > 6.3 on a 7-point scale). The highest-rated dimensions were understanding cultural differences ($M = 6.9$, $SD = 0.3$) and learning from experience ($M = 6.9$, $SD = 0.3$), confirming that the Mexico service-learning experience fostered intercultural and experiential learning. The lowest-scoring item, though still high, was leadership development ($M = 6.3$, $SD = 0.7$), suggesting that leadership growth may require sustained engagement over time.

The qualitative reflections collected through post-mobility discussions revealed three key themes:

- Transformation through immersion: Students emphasized that direct contact with Mexican peers and communities changed their perception of cultural diversity and global interdependence.
  "*I realized that collaboration is not just about language; it's about empathy and flexibility*." (Student1)
- Linking theory to practice: Many participants valued the opportunity to apply disciplinary knowledge (e.g., engineering, education, or health) in real contexts.
  "*Teaching statistical thinking to local NGOs made me understand the social purpose of what we learn at university*." (Student2)
- Emotional engagement and motivation: The project's human-centered approach enhanced student motivation, resilience, and commitment to civic engagement.

4.1. The Mexico service-learning experience

The transnational service-learning activity took place in Morelia, Mexico, and represented the culmination of the project's collaborative cycle. The activity brought together 20 students and 16

faculty/staff from Spain, Portugal, Romania, and Mexico. Over a week, participants worked in interdisciplinary teams on three thematic projects:

1. Health and well-being: In collaboration with local NGOs, students developed awareness campaigns about leukemia and bone marrow donation.
2. Education for sustainability: Teams implemented educational workshops integrating science and creativity to teach sustainability concepts to children.
3. Community innovation and leadership: Mixed teams co-designed service initiatives addressing community needs, such as social inclusion and digital literacy.

These activities embodied the principles of experiential and intercultural learning, fostering empathy and mutual respect among participants. Faculty members observed that the joint reflection sessions — where students discussed challenges, emotions, and lessons learned — were critical in transforming experience into meaningful learning.

5. Discussion

The findings confirm that international service-learning within an Erasmus+ cooperation partnership can significantly enhance both student learning and institutional innovation.

The SELEB results indicate that participation in the Mexico mobility strengthened students' intercultural competence, social responsibility, and capacity to connect theory with practice — dimensions that align closely with the aims of innovation pedagogy (Keinänen & Kairisto-Mertanen, 2019) and the principles of European higher education modernization (Ovtšarenko et al., 2024).

Institutional data complement these results, showing that universities and associated partners recognized the project's value in promoting pedagogical innovation and transnational collaboration. These findings are consistent with previous research (Queiruga-Dios et al., 2021; Hernández Encinas et al., 2025; Mierlus Mazilu et al., 2025) highlighting that service-learning provides a robust framework for integrating academic learning, employability skills, and civic engagement.

However, some challenges remain. As Fumasoli and Rossi (2021) note, institutional innovation requires long-term support and recognition. The project's reliance on short-term mobilities limited the continuity of activities and the consolidation of student leadership roles — explaining why leadership development received slightly lower SELEB scores.

Nevertheless, the transnational, interdisciplinary nature of the GIRLS project demonstrates that when universities, research institutions, and NGOs collaborate, they can co-create inclusive, globally relevant educational experiences that embody the Sustainable Development Goals (SDGs) principles of partnership, quality education, and reduced inequalities.

6. Conclusions

This study demonstrates the transformative potential of Erasmus+ cooperation partnerships as engines of pedagogical innovation and internationalization in higher education. The integration of service-learning and active learning methodologies within the project fostered deep learning, intercultural awareness, and civic engagement among students while simultaneously strengthening institutional capacity for innovation and transnational collaboration.

The mixed-methods results confirm that participants experienced significant personal and academic growth through the Mexico service-learning experience, particularly in developing empathy, social responsibility, and the ability to connect theory with practice. These outcomes reflect the core principles of innovation pedagogy and align with the objectives of the European Education Area and the Sustainable Development Goals.

Although some challenges remain such as the need for stronger institutional support to ensure the long-term sustainability of innovations, the overall evidence indicates that transnational service-learning initiatives provide a powerful framework for transforming teaching and learning. This project illustrates how European cooperation can foster not only academic excellence but also social impact, preparing students to become globally competent, empathetic, and socially responsible professionals.

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PEER POWER IN PRACTICE: A SYSTEMATIC REVIEW OF PEER PROGRAMS SUPPORTING INCLUSIVE AND SUPPORTIVE SCHOOL ENVIRONMENTS

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Abstract

In today's multicultural and interconnected societies, as schools and classrooms become more diverse, promoting inclusive attitudes and supportive learning environments is a central challenge for education systems. Present systematic review synthesizes evidence on the effectiveness of peer programs — including mentoring, tutoring, teaching, and peer support initiatives — in enhancing inclusivity within schools. A systematic search was conducted in Web of Science, Scopus, and ERIC for studies published between 2015 and 2024, following PRISMA 2020 guidelines. No review protocol was registered. Fifteen peer-reviewed articles were included based on criteria such as implementation in general education from grade 1 to grade 12 and a clear goal of improving community, social interactions, school climate, students' attitudes, acceptance of differences, or overall inclusivity. Methodological quality was appraised using the Mixed Methods Appraisal Tool (MMAT), with most studies meeting all criteria. Findings demonstrate that peer programs are generally associated with improvements in inclusive attitudes, empathy, and community engagement, contributing to improved school climate and student well-being, while also supporting academic goals. Future research should expand the geographic scope of peer program studies and incorporate longitudinal designs to better understand their sustained impact across diverse educational contexts.

Keywords: *Systematic literature review, peer programs, inclusive education, community development, school inclusion.*

1. Introduction

In culturally diverse and interconnected societies, schools play a central role in promoting inclusion, belonging, and social cohesion. As classrooms become more heterogeneous, educators increasingly rely on peer-led initiatives—such as mentoring, tutoring, and peer support—to strengthen interpersonal relationships and foster acceptance among students (Ainscow, 2016; Lee, Cha, & Ham, 2023; Nicaise, 2013). Previous reviews have examined specific subfields of peer programs, yet many were limited by narrow participant groups (Kuntz & Carter, 2019), older datasets (Bowman-Perrott, Burke, Zhang, & Zaini, 2014; Watts, Bryant, & Carroll, 2018), or single-country contexts (Palomero-Fernández, Cáceres-Iglesias, & Torrego-Egido, 2024). To address these gaps, this review synthesizes recent empirical evidence on how peer programs contribute to inclusive attitudes, social skills, and supportive school climates in general education settings. Our analysis is grounded in theoretical perspectives on inclusive education and peer-mediated learning, emphasizing the role of structured peer interactions and the strong influence of peer norms in shaping students' social attitudes and school climate.

2. Methods

2.1. Search strategy and selection

The systematic search followed PRISMA 2020 guidelines (Page et al., 2021). Studies published between 2015 and 2024 were identified in Web of Science, Scopus, and ERIC using keywords related to peer mentoring, tutoring, teaching, and peer support. In addition to database searches, we conducted a backward citation search by screening the reference lists of relevant reviews to capture studies not retrieved through database queries. After removing duplicates and screening titles, abstracts, and full texts, fifteen

studies met the predefined inclusion criteria. This final set reflects the combined results of the systematic search and citation screening. The criteria focused on empirical research in general education (grades 1–12) explicitly targeting inclusive attitudes, school climate, social interactions, or community development. Although the initial search yielded a large number of records, only studies addressing peer programs with explicit inclusion-related aims were retained.

2.2. Data extraction and synthesis

Data extraction was conducted using a standardized template that defined the main deductive categories, including study characteristics, participant groups, program types, objectives, and outcomes. In parallel, inductive coding allowed additional themes to emerge, ensuring that recurrent patterns were captured beyond the predefined categories. The identification of key factors therefore relied on a combined deductive–inductive coding process, in which structured categories were complemented by emergent themes (Braun & Clarke, 2006). Studies were included if they reported both individual-level outcomes (e.g., social skills, self-esteem) and school- or community-level effects (e.g., climate, peer relationships, inclusivity), while studies focusing solely on individual improvement without broader social implications were excluded. The findings were synthesized using a narrative synthesis approach guided by inductively derived thematic categories (Green, Johnson, & Adams, 2006). Narrative synthesis enabled the systematic organization of evidence in relation to the review's aims, while thematic analysis highlighted recurrent objectives and outcomes across studies (Braun & Clarke, 2006). Coding was guided directly by the three research questions, and the resulting thematic structure of the Results section reflects this alignment: the analysis first examined how peer programs relate to the development of inclusive attitudes and acceptance among students in general education settings (RQ1), then explored the ways in which peer-led initiatives contribute to a positive school climate and enhance students' social skills and empathy (RQ2), and finally investigated the perceived benefits and challenges of peer programs in fostering community development within schools (RQ3). This combined analytic approach allowed diverse study designs and outcome measures to be integrated into a coherent descriptive synthesis.

2.3. Quality appraisal

Methodological quality was assessed using the Mixed Methods Appraisal Tool (MMAT) (Hong et al., 2018). Each study was evaluated according to its methodological design, and ratings were assigned based on the five MMAT criteria. Fourteen studies met all applicable criteria, and one mixed methods study showed partial fulfillment due to insufficient interpretation of the integrated qualitative and quantitative findings. Although most studies demonstrated strong methodological reporting, typical limitations such as small samples or context-specific designs remain important to consider when interpreting the findings. The MMAT process ensured transparency and comparability across diverse research designs, addressing concerns about risk of bias and strengthening the credibility of the synthesis.

3. Results

3.1. Thematic overview of included studies

Peer mentoring, cross-age tutoring, and structured peer support initiatives were the most frequently implemented approaches across the included studies. Program duration varied considerably, ranging from short-term interventions lasting only a few weeks to year-long initiatives embedded in school routines. Despite this variability, all studies reported outcomes related to inclusion, social skills, empathy, or school climate, indicating a consistent pattern across contexts. Several studies also highlighted that peer-led interactions can strengthen students' sense of belonging and community engagement, suggesting that peer programs contribute to both individual and school-level social development.

3.2. Inclusive attitudes and acceptance

Across the included studies, peer programs were consistently associated with improvements in inclusive attitudes and acceptance. Several studies reported increased empathy, openness to diversity, and more positive perceptions of peers with different abilities or backgrounds (Alegre Ansuategui & Moliner Miravet, 2017; Asmus et al., 2017; Barahona, Padrón, & Waxman, 2023; Carter et al., 2016; Haft, Chen, LeBlanc, Tencza, & Hoeft, 2019; Martí Ballester & Moliner Miravet, 2015). Programs involving structured interaction with students with disabilities showed particularly strong attitudinal shifts, suggesting that direct peer engagement can reduce social distance and foster appreciation of differences. These findings align with the thematic category of attitudinal change identified during coding and are consistent with broader theoretical perspectives on the role of peer influence in shaping social attitudes. At the same time, some studies relied on small or context-specific samples (Scheef & Buyserie, 2020; Toulia, Strogilos,

& Avramidis, 2023), which may limit the strength and generalizability of attitudinal findings. Overall, the evidence suggests that peer programs contribute to more inclusive and accepting classroom environments.

3.3. School climate, social skills, and empathy

Across the included studies, peer-led initiatives were consistently linked to improvements in school climate and students' socio-emotional competencies. Multiple studies reported gains in communication, cooperation, and conflict-resolution skills, alongside increases in empathy and prosocial behavior (Asmus et al., 2017; Capp, Benbenishty, Astor, & Pineda, 2018; Carvalho & Santos, 2021; Cockerill, Craig, & Thurston, 2018; Thurstonet al., 2018; Kondo & Kato, 2023, 2024). Other studies described improvements in social competence and peer interaction quality (Scheef & Buyserie, 2020; Toulia et al., 2023), indicating that peer programs can strengthen interpersonal relationships and contribute to a more collaborative classroom atmosphere. Several studies noted reductions in behavioral issues and increased self-confidence among participants, suggesting stronger student connection to the school community. At the same time, some studies relied on small or context-specific samples (Alegre Ansuategui & Moliner Miravet, 2017; Gvaldaitė, Budreckaitė, & Bučinskienė, 2024; Toulia et al., 2023), which may limit the strength of the evidence for school-climate improvements. These patterns align with the thematic category of socio-emotional development identified during coding.

3.4. Community development and implementation challenges

Peer programs were also associated with broader community-level benefits, including increased student engagement, stronger peer networks, and a heightened sense of responsibility toward others (Barahona et al., 2023; Carvalho & Santos, 2021; Kondo & Kato, 2023; Kondo & Kato, 2024; Thurston et al., 2020). Several studies described how peer helpers or mentors contributed to a more positive school environment by facilitating cooperation, supporting classmates, or participating in community-building activities. Some studies also reported improvements in peer interaction quality and community involvement (Scheef & Buyserie, 2020), suggesting that peer programs can strengthen school-level social cohesion. Challenges were also reported across multiple studies, such as inconsistent implementation, limited mentor training, scheduling difficulties, or declining engagement over time (Capp et al., 2018; Gvaldaitė et al., 2024; Martí Ballester & Moliner Miravet, 2015). Some studies also faced methodological constraints, such as small or demographically unclear samples (Gvaldaitė et al., 2024; Martí Ballester & Moliner Miravet, 2015; Scheef & Buyserie, 2020), which limit the generalizability of community-level findings. In some cases, unequal benefits across student groups or unclear tutor outcomes were noted, highlighting the importance of structured planning and adequate preparation. The challenges identified during coding underscore the need for careful program design to maximize positive impact.

4. Discussion

The findings of this review confirm that peer programs play a meaningful role in strengthening inclusive attitudes, empathy, and social relationships in diverse school settings. Consistent with earlier work on inclusive education, structured peer interactions supported students in developing openness and acceptance toward peers with different abilities or backgrounds (Ainscow, 2016; Booth & Ainscow, 2011). These outcomes align with broader perspectives emphasizing the importance of collaborative learning environments and peer norms in shaping belonging and school climate. Our synthesis highlights substantial variation in program duration, structure, and facilitation, indicating that peer programs are adaptable but not uniform in their implementation. Short-term initiatives tended to produce immediate social benefits, whereas longer-term programs were more likely to influence school climate and community cohesion. This review contributes new insights by offering a contemporary and systematically organized overview of peer programs in general education settings. Unlike earlier reviews that focused on narrow participant groups or relied on older datasets, our analysis incorporates recent studies across diverse student populations and geographic contexts, providing a more current understanding of how peer programs function in today's schools. A further contribution lies in the systematic mapping of program objectives across the included studies, which reveals a wide range of social and attitudinal aims that extend beyond academic outcomes—an aspect often overlooked in previous syntheses (Williams, Chen, & Quirion, 2024). Finally, the review underscores the need for structured mentor training, consistent implementation, and equity-focused monitoring to ensure that peer programs achieve their intended impact. While the overall methodological quality was strong, the diversity of designs and outcome measures highlights the importance of more rigorous, longitudinal, and context-sensitive research to guide sustainable and inclusive educational practice.

5. Limitations

Although this review provides an up-to-date synthesis of peer programs supporting inclusive school environments, several limitations must be acknowledged. Restricting the search to peer-reviewed studies published between 2015 and 2024 in three major databases may have excluded earlier or grey-literature research. Although no language restrictions were applied, few non-English studies met the criteria. Variability in reporting quality—such as missing details on program duration, mentor training, or participant characteristics—reduced comparability across studies. Many included studies relied on small samples, non-randomized designs, self-report measures, and lacked long-term follow-up, limiting the robustness and generalizability of the evidence. The limited number of eligible studies reflects the current scarcity of high-quality empirical research specifically examining inclusion-focused peer programs, rather than a constraint of the review's methodological scope.

6. Conclusion

Peer programs hold significant potential for fostering inclusive attitudes, empathy, and positive school climates. The findings of this review demonstrate that structured peer interactions can strengthen social relationships and support a more accepting classroom environment across diverse educational contexts. At the same time, the evidence base remains uneven, with considerable variation in study quality, design, and reporting. When carefully planned and supported through mentor training and program fidelity, peer programs can meaningfully contribute to mutual respect and appreciation of diversity—core aims of inclusive and multicultural education. To deepen understanding and strengthen the evidence base, future research should broaden geographic representation, employ longitudinal designs, and examine developmental differences more systematically. Together, these efforts can help schools implement peer programs that are both equitable and sustainable.

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FROM ALGORITHM TO UNDERSTANDING: THE ROLE OF AI LITERACY IN STUDENT ACCEPTANCE OF AI GRADING

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Abstract

AI grading systems are increasingly integrated into higher education, yet their acceptance cannot be taken for granted. Building on the Technology Acceptance Model for AI Grading (TAM-AIG) introduced at the 2025 END Conference, this study examines whether AI literacy, defined as structured student preparation on how large language model graders operate, functions as a scalable intervention to improve fairness and trust perceptions. A between-subjects field experiment conducted during Fall 2025 in a graduate business course employed four grading conditions and two assignments varying in stakes. Results confirm that the AI literacy intervention significantly improved perceived fairness (p = .021) and trust (p = .026); that transparency strongly predicted fairness (r = .64, p < .001); and that fairness remained the central predictor of satisfaction (r = .75, p < .001). Assignment stakes produced no significant effect on trust, but GPA moderated fairness perceptions in AI-only conditions. These findings extend the TAM-AIG framework and offer actionable guidance for institutions integrating AI into academic assessment.

Keywords: *Artificial Intelligence, AI literacy, AI grading, Technology Acceptance Model, higher education.*

1. Introduction

The growing use of AI in higher education assessment has outpaced our understanding of how students actually experience it. While debates about academic integrity and AI-generated content dominate the public conversation, a quieter but equally consequential question is taking shape in real classrooms: when AI evaluates student work, do students accept that judgment as fair? This is not only a question of whether AI grades accurately. It is equally about how students perceive being graded by AI. Prior research shows that feelings of fairness and trust do not always result just because a system performs well (Chai et al., 2024; Hsu et al., 2021).

Our 2025 END Conference study introduced the Technology Acceptance Model for AI Grading (TAM-AIG), finding that framing AI as collaborative - pairing AI evaluation with human oversight - significantly improved students' perceptions of fairness and satisfaction compared with both human-only and fully autonomous AI conditions (Noel, King, & Sabin, 2025). Usefulness of feedback, rather than consistency, was the strongest predictor of trust, and transparency consistently improved perceptions of fairness.

Specifically, we examine whether an AI literacy intervention, defined as a structured explanation of how large language model graders process text, apply rubrics, and operate under instructor oversight, meaningfully improves how students evaluate AI grading systems. If transparency and oversight are system-design features that require institutional investment, AI literacy is something that can be embedded in a course syllabus or pre-assignment communication at minimal cost. If this approach is effective, it can be applied broadly and reach many students. That's exactly why understanding this difference is important.

Prior research on algorithmic aversion (Dietvorst, Simmons, & Massey, 2015) suggests that people distrust automated systems even when those systems outperform human alternatives. However, aversion and acceptance are not simply inverses of each other. According to the TAM-AIG framework, students' acceptance of AI grading depends on whether they perceive the process as fair and trustworthy - factors influenced by how institutions present and communicate about the system.

2. Theoretical framework

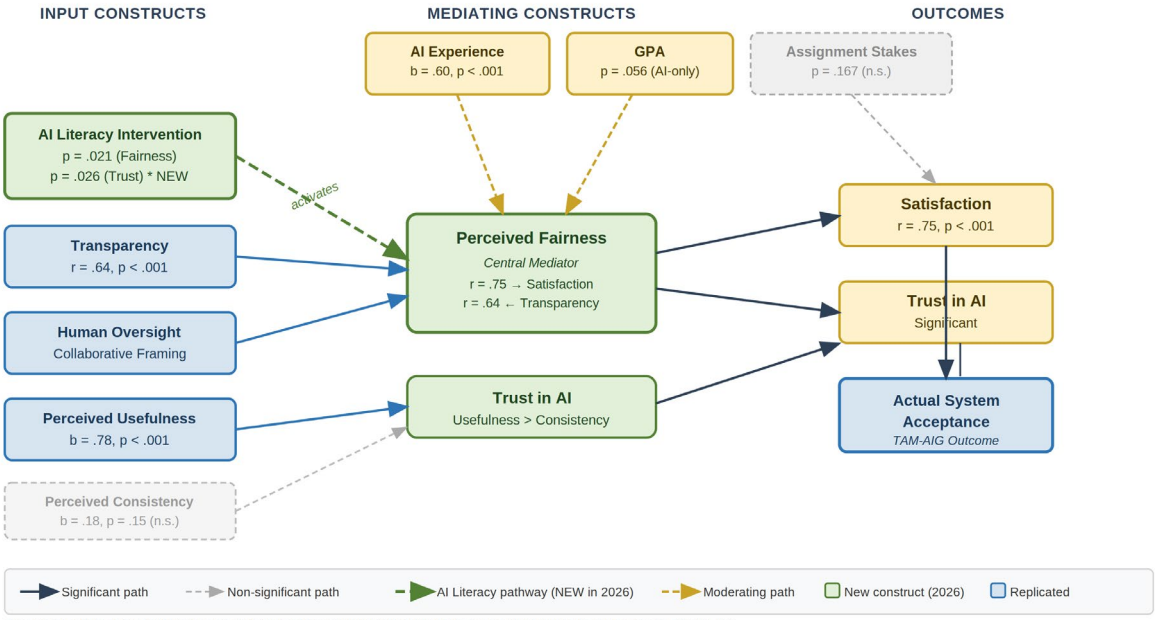
The Technology Acceptance Model (Venkatesh & Davis, 2000) posits that perceived usefulness and ease of use are the primary drivers of technology adoption. These constructs fit reasonably well in consumer technology contexts, but grading is a fundamentally different kind of interaction. Students do not choose to adopt a technology; they are evaluated by one. That asymmetry changes the relevant constructs

entirely. Fairness, transparency, and accountability become central in ways they are not when someone simply adopts a consumer technology tool.

TAM-AIG was developed to address this gap directly. It extends the original framework with six constructs - Perceived Fairness, Transparency, Trust in AI, Usefulness, Consistency, and Human Oversight - and positions Perceived Fairness as the central mediating variable between system design features and student outcomes such as satisfaction and trust. The 2025 END Conference study validated the basic framework: Transparency leads to Fairness, which in turn leads to Satisfaction and Trust, with Usefulness outperforming Consistency as a predictor of Trust.

The present study introduces AI Literacy as a new intervention variable within this framework. Drawing on Long and Magerko's (2020) competency model and Ding et al.'s (2024) work on structured professional preparation, we define AI literacy here as students' structured exposure to information about how LLM graders evaluate text, their limitations, and how instructor oversight is exercised. This intervention is different from simply sharing the rubric or changing the system itself - it helps students better understand how the grading system operates before they submit their work. Eight hypotheses were derived from the extended framework; H8, the primary new hypothesis, tests whether the AI literacy intervention independently improves fairness and trust perceptions after controlling for grading condition and assignment stakes. The extended model is presented in Figure 1.

Figure 1. Extended TAM-AIG Model: From Algorithm to Understanding (2026).



Note. Solid arrows indicate significant paths; dashed gray arrows indicate non-significant paths. The dashed green path represents the AI Literacy Intervention, a new construct introduced in the 2026 extension of TAM-AIG that activates the Transparency to Fairness pathway. Moderating paths are shown in gold dashed lines. AI Experience was a significant positive moderator (b = .60, p < .001); GPA produced a marginal moderating effect concentrated in the AI-only condition (p = .056); Assignment Stakes did not significantly moderate any outcome (p = .167). Path coefficients are from Study 2 (N = 89, graduate business students, Fall 2025). The 2025 END Conference study (N = 125) did not include the AI Literacy construct.

3. Experimental design

A between-subjects field experiment was conducted in two sections of a graduate business course at a large public Midwestern university in Fall 2025 (N = 89 students). Students were randomly assigned to one of four grading conditions: (A) Human-only grading; (B) AI with human oversight; (C) AI-only; and (D) Transparent AI with rubric disclosure. Conditions B and D also received an AI literacy intervention: a written explanation embedded before each assignment describing how the LLM grader processes student responses, how rubric criteria are weighted, the types of errors AI graders are prone to making, and how instructor review is structured. Conditions A and C received no such preparation.

Two assignments were included to test whether assignment stakes moderated perceptions: a high-stakes case analysis (MMBC) and a lower-stakes formative exercise (ADPLANE). Baseline and post-assignment surveys measured all six TAM-AIG constructs using established Likert-scale items (1 to 7 scale). GPA and prior AI experience were collected as potential moderator variables. Internal consistency was acceptable across all scales (Cronbach's alpha > .78). Analyses included ANOVA, correlational analysis, moderated regression, and structural equation modeling.

4. Results

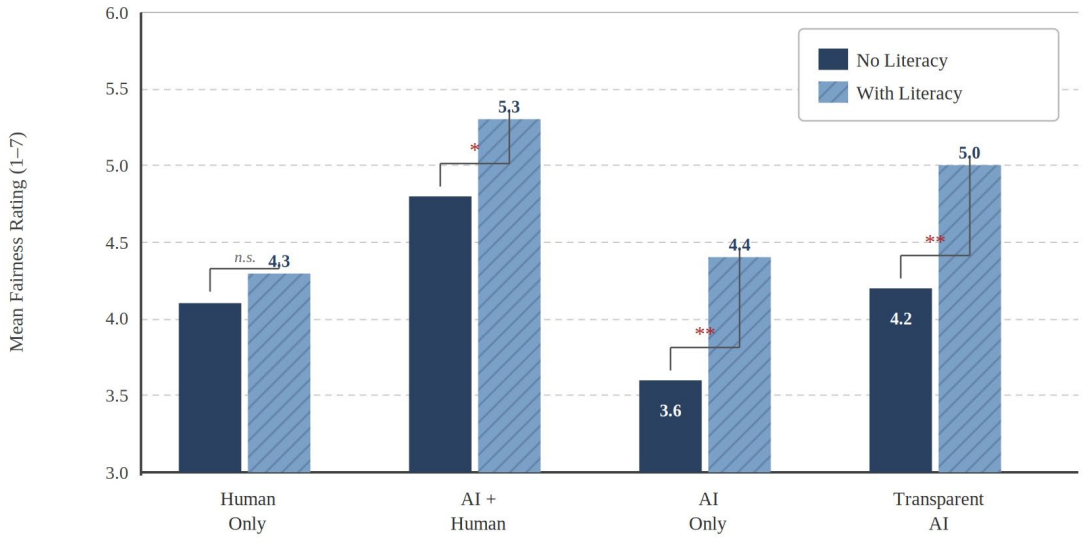
Table 1. Summary of Hypotheses and Results.

H	Hypothesis	Key Statistic	Result
H1	Collaborative AI framing increases fairness perceptions	p = .111	Partially Supported
H2	Perceived fairness positively predicts satisfaction	r = .75, p < .001	Supported
H3	Transparency positively predicts fairness perceptions	r = .64, p < .001	Supported
H4	Prior AI exposure predicts fairness and satisfaction	b significant	Supported
H5	Trust is higher for low-stakes assignments	p = .167	Not Supported
H6	Consistency predicts trust more strongly than usefulness	Usefulness stronger	Not Supported
H7	GPA moderates fairness in AI-only conditions	p = .056	Marginally Supported
H8	AI literacy intervention increases fairness and trust	p = .021 / .026	Supported

The central TAM-AIG relationships replicated cleanly across this new sample. Fairness strongly predicted Satisfaction (r = .75, p < .001), Transparency significantly predicted Fairness (r = .64, p < .001), and Usefulness predicted Trust more strongly than Consistency. This pattern was first documented in the 2025 END Conference study and is now independently replicated in a different semester, a different student cohort, and a more consequential grading context.

Primary Finding: AI Literacy and Acceptance. The most important finding is the support for H8. Students who received the AI literacy intervention rated grading as significantly fairer (p = .021) and reported significantly higher trust (p = .026) compared to those in control conditions, after controlling for grading condition and assignment stakes. These effects were not driven by any single grading condition; the literacy advantage appeared across all four conditions, with the largest absolute gain observed in the AI-only condition (estimated mean difference of approximately 0.8 scale points on the 7-point fairness measure). This is notable because the AI-only condition also showed the lowest baseline fairness ratings, suggesting that literacy interventions may have their greatest practical impact precisely where students are most skeptical.

Figure 2. Mean Fairness Ratings by Grading Condition and AI Literacy Intervention.



** p < .05 ** p < .01 n.s. = not significant. Error bars omitted for visual clarity.*
Literacy intervention embedded in AI + Human (Condition B) and Transparent AI (Condition D) only.

*Note. Dark bars = No Literacy; hatched bars = With Literacy. Literacy intervention in Conditions B and D only. Significance brackets: * p < .05; ** p < .01; n.s. = not significant. Scale: 1 = Strongly Disagree, 7 = Strongly Agree.*

Assignment Stakes. H5 was not supported. Trust levels did not differ significantly between the high-stakes MMBC case analysis and the low-stakes ADPLANE formative exercise (p = .167). This finding directly contradicts the assumption that AI grading resistance is primarily a high-stakes phenomenon. How the grading system is explained and structured matters more than how much the grade affects students'

academic standing. Figure 2 shows how fairness ratings varied across grading conditions and literacy interventions.

Collaborative Framing. H1 received only partial support. Students in the collaborative AI condition reported the highest fairness ratings numerically, but differences across conditions did not reach significance thresholds (p = .111). The 2025 END Conference study (N = 125, mixed undergraduate and graduate marketing students) found a significant framing effect. The present graduate-only sample, drawn from business programs with higher baseline AI experience, may have been less responsive to the collaborative framing cue. Alternatively, the AI literacy intervention in conditions B and D may have partially substituted for the framing effect.

GPA Moderation. H7 showed a marginal moderating effect (p = .056) absent in the original 2025 study, where GPA showed no significant association with fairness (b = -.06, p = .47) or satisfaction (b = -.15, p = .07). A more plausible explanation lies in sample composition: the present study sampled exclusively from graduate business programs, where academic performance carries stronger professional implications. High-GPA students may be uniquely sensitive to algorithmic substitution where professional identity and credentialing concerns are most salient.

5. Discussion

These results support and extend the TAM-AIG framework. The core relationships replicated across a different semester, a different sample, and a more consequential grading context. Fairness predicted Satisfaction, Transparency predicted Fairness, and Usefulness outpaced Consistency in predicting Trust.

The primary new finding is the effect of the AI literacy intervention. Students who received a structured explanation of how the LLM grader worked - including its limitations and the role of instructor oversight - rated the grading experience as fairer and reported higher trust. What is notable is that the intervention required no change to the grading system itself, only to what students were told before their assignment was evaluated. Institutions can meaningfully improve student acceptance through communication and preparation alone, without modifying how the AI system functions.

We did not find support for H5. Students' fairness and trust ratings appear driven by how the grading system is presented and explained, rather than by how much the grade matters. These findings suggest that student acceptance of AI grading is shaped substantially by how the system is introduced. Institutions considering AI-assisted grading would do well to invest as much attention in student preparation as in system selection.

6. Limitations

Several limitations bound the interpretation of these findings. The study was conducted within a single business school, limiting generalizability across disciplines. Replication with more diverse samples - including undergraduate students, students with limited AI experience, and students in non-Western academic contexts - would strengthen confidence in the generalizability of the TAM-AIG framework. The AI literacy intervention was delivered only in written form, which prevents us from isolating which components drove the observed effects; future research should compare written, video-based, and instructor-facilitated formats. All surveys relied on self-report measures, subject to demand characteristics and social desirability bias. In addition, the sample size was small, which reduced the power of the results.

7. Future research

The most pressing priority is longitudinal: we do not yet know whether the fairness and trust gains persist across multiple graded assignments, or whether they attenuate as algorithmic evaluation becomes routine. A second priority is the integration of instructor perceptions into the framework - faculty skepticism may undermine student trust regardless of what the literacy intervention says. Cross-disciplinary replication studies would further test whether the TAM-AIG construct relationships hold in engineering, the liberal arts, and the health professions.

8. Practical recommendations

Table 2. Practical Recommendations for AI Grading Implementation.

Principle	Recommendation
AI Literacy First	Provide a brief written explanation before the assignment describing how the LLM grader processes text, applies the rubric, and where instructor review occurs. A single page of preparation improved fairness (p = .021) and trust (p = .026).
Make Rubrics Visible	Share grading rubrics openly and explain specifically how criteria are weighted in the AI system. Visible grading logic increases transparency perceptions, which directly drive fairness ratings.

Principle	Recommendation
Frame AI as Collaborative	Position AI as a grading assistant, not a replacement evaluator. Students in AI with Human Oversight conditions reported the highest fairness ratings. Framing accountability as shared with the instructor sustains legitimacy.
Prioritize Feedback Usefulness	Ensure AI-generated feedback is substantive and learning-focused. Usefulness of feedback predicted trust more strongly than consistency: accuracy of the grade mattered less than the quality of the explanation.
Create a Visible Appeals Path	Explicitly communicate that students may request instructor review of AI-generated grades. The mere availability of an appeals mechanism sustains procedural fairness, even when rarely invoked.

9. Conclusion

This study extends the TAM-AIG framework by introducing AI literacy as a structured intervention that improves students' fairness and trust perceptions in AI-assisted grading contexts. We found that students who received a brief explanation of how the LLM grader operates - including its limitations and the role of instructor oversight - rated the experience as significantly fairer and reported higher trust than those who did not. These effects held regardless of assignment stakes, suggesting that students' responses to AI grading are driven more by how the system is explained than by the grade's consequences.

The TAM-AIG framework, now tested across two independent studies, continues to show that Transparency predicts Fairness, Fairness predicts Satisfaction and Trust, and Usefulness of feedback is a stronger predictor of Trust than Consistency. A simple literacy intervention delivered before the first graded assignment appears to be a low-cost, scalable way to improve student acceptance. Combined with collaborative framing that makes human oversight visible, this approach is likely to produce more positive student responses than AI-only grading without explanation. We hope these findings are useful to educators and administrators working to implement AI grading thoughtfully.

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CO-DESIGN WITH TIMORESE ARTISTS: PRACTICE-LED REFLECTIONS ON DESIGN FOR DEVELOPMENT IN TIMOR-LESTE

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Abstract

This paper presents a practice-led co-design project developed in East Timor with a group of Timorese artists, in 2025 coordinated by European experts in markets and design. Although the project had a twofold approach (design and markets), the current text focuses on the design outcomes of the project. Despite the Portuguese participants' cultural and historical links with East Timor, socio-cultural assumptions were not valid, as the knowledge of the local reality was narrow, the resources were scarce, the communication channels were limited, and there was a language barrier. The reality of East Timor is shaped by historical challenges and an ongoing economic crisis, where more than 41% of the population lives below the poverty line World Bank (2023). Despite this, a striving and highly dynamic community of artists has been shaping the identity of one of the youngest countries in the world. What started as a training and advisory program in brand design and product development ended as a larger and more sustainable project that included the creation of an open-source toolkit and event curation. The project engaged contemporary Timorese artists in a hybrid collaborative design process focused on brand identity and sustainable product development and businesses. The process was highly iterative, and the method combined co-creation design principles (Sanders & Stappers) and the horizontal framework of Mazzarotto's cultural synthesis, based on Paulo Freire, where designers and participants merge their expertise and local/community know-how, aiming at a socially conscious and sustainable outcomes. The project results included a collection of art-based merchandising products, a cultural event and exhibition in Dili, a catalogue, and an open source toolkit specially designed for the art community in East Timor, built from the learning process of the designers and experts. This last outcome was driven by the need for long-term follow-up mechanisms and knowledge transfer, which endangered the societal impact of this initiative. This paper argues that, in such realities, influenced by economic and social inequalities, a co-design approach should propose a more resilient approach that embeds the post-project continuity into the design process itself. By presenting the design journey, the designed products and toolkit and participant feedback, this paper also illustrates how co-design projects in a country with significant developmental challenges, but with a vibrant artistic community, should privilege situated learning, local ownership and equity over predetermined assumptions.

Keywords: *Co-design, East Timor, social sustainability, cultural synthesis, knowledge transfer.*

1. Introduction

This paper presents a project that gathered European designers, a creative market expert and Timorese artists. It started in October 2024 and ran until October 2025 in Dili, Timor-Leste. The main goal was to foster local artists and their creative businesses. Starting as a training and advisory program in brand design and product development, this project evolved towards a co-design program and turned into a larger and more sustainable project that included the creation of an open source toolkit and event curation. The final project engaged a small group of Timorese artists in a hybrid collaborative design process focused on brand identity and sustainable product development and businesses. Considering the twofold topics of work – design and markets – this paper will focus on the development of the co-design program, product development, and final exhibition design.

2. Timor-Leste context and cultural heritage

Timor-Leste is the youngest country in Asia, marked by economic and social struggles, since it gained its independence in 2002. According to the World Bank (2023), more than 41% of Timor-Leste's

population lives below the national poverty line. Despite these challenges, the Timorese people demonstrate remarkable interest in the sectors of art and culture that are growing in activity.

"While formal pathways for artistic education remain limited, community groups continue to nurture emerging talent. Artists and cultural workers in Timor-Leste have largely shaped their practices as livelihoods deeply rooted in rich intangible cultural heritage. This potential must be strategically leveraged to ensure that safeguarding living heritage and cultural industry growth go hand in hand." (UNESCO, 2026)

Timor-Leste also has one of the youngest populations in Asia, with youth representing more than 70% of its population (UNFPA, 2022). And this reflects in a cultural ecosystem developed by young artists and fueled by the civil society. A community gathered around strong values of national identity and ancestrality, deep relation with nature and resilience. The reality shows that formal education in the arts is scarce, and the main drivers of arts and cultural development are institutions such as Arte Moris. Established in 2003, Arte Moris (which means "Living Art" in Tétum) is a free school that aims to use art and creativity as a means to express a collective and individual identity while simultaneously serving as a tool for healing from the brutal military occupation of the previous decades.

3. The challenges of a co-design program

The Timor-Leste Art Project was initially proposed by the European Union Delegation in Dili, with the support of the Cultural Relations Platform, a EU-funded project that connects artists and *cultural* agents from around the world for dialogue, exchange and cooperation (CRP).

Recognising the need for capacity-building in the fields of innovative product design and entrepreneurial competencies among Timorese artists, these institutions funded a training program aimed at a group of artists to help them develop their careers and businesses, conducted by Designers and a Branding and Market expert.

The initial briefing proposed by the CRP was to translate artworks into merchandise products and build a branding strategy. Products that could meet consumer expectations in creativity, originality, quality and sustainability. The project also aimed to create business strategies and build brands that could access international markets, and the European market in particular. Considering this briefing, our first challenge was to reevaluate the project's objectives, methodology, and deliverables. As European designers, the risk of trying to "solve" the problem of "others" by applying a supposedly universal method seemed obvious.

Although the designers were Portuguese with historical ties to Timor-Leste, their understanding of the local context was limited due to scarce resources and language barriers. To address this, we connected with a trusted member of the Dili art community who helped us gather a group of ten artists who would take part in this project. The first stage was to understand the reality better and to redefine the objectives of the program. After some online meetings, we slowly started to build a relationship based on trust and mutual understanding that allowed us to redesign the programs' initial goals. In this context, the project evolved from a European-led standard training program into a co-design program, a locally-driven collaboration work emphasising continuity, ownership, and creative sustainability.

Drawing on Visser et al. (2005), the project reframed artists as "experts on their experience domains", replacing top-down design with collective authorship. Considering Sanders and Stappers (2008) definition of design process, we also reenvisioned the training program as a co-design program.

> *The authors take co-creation to refer to any act of collective creativity, i.e. creativity that is shared by two or more people. (...) co-design is a specific instance of co-creation. Co-design refers, for some people, to the collective creativity of collaborating designers. We use co-design in a broader sense to refer to the creativity of designers and people not trained in design working together in the design development process. (Sanders & Stappers, 2008)*

In theoretical terms, the work follows Mazzarotto's (2024) concept of cultural synthesis, inspired by Paulo Freire's (2020) dialogic pedagogy and the assumption that "No one educates anyone — no one educates himself — men educate each other, mediated by the world." (Freire, 2000)

The brazilian educator and philosopher Paulo Freire, supported his methodology on a ethical-critical-political-educational perspective (UNESCO, 2017). In response to the cultural invasion – where the invasors impose their own worldview upon the cultural context of the invaded while curbing their creativity – he proposes a cultural synthesis, where the historical leaders and oppressors engage in a dialogical praxis of understanding and collective transformation:

> *...Instead of following predetermined plans, leaders and people, identifying together, create the guidelines of their action. In this synthesis, leaders and people are somehow reborn in new knowledge and new action [...] Cultural synthesis does not deny the differences between the two views; indeed, it is based on these differences. It does deny the invasion of one by the other, but affirms the undeniable support each gives to the other. (Freire 2000)*

Mazzarotto and Serpa (2024) build on Freire's epistemology to reflect about Design as cultural invasion and how this concept of cultural synthesis can occur in today's social structures.

> *Synthesis is, above all, a critical and transformative dialogue in which both designers and the community become different from what they were before, through the creation of new knowledge and practices that were only made possible by the richness of the different voices and histories involved. It is a complex process that takes time, demands the creation of bonds of solidarity, and requires respect for local culture and mechanisms of dialogue and mediation.*[*] *(Mazzarotto & Serpa, 2022)*

This approach was instrumental in the current project, as we recognized the risks associated with creating or maintaining anti-dialogical actions. These risks included 1) imposing a moral, technical and cultural authority by means of a "One-World World" point of view, instead of understanding "(…) a world where many worlds fit" (Escobar, 2018) and 2) a over "designerly" way of thinking, as Lorusso explains: "To maintain the wealth of preexisting relationships–be they historical, political, or cultural–design should resist the temptation to formalize, to abstract, to be *the* relation." (Lorusso, 2021)

We also understood quickly that the project should have a revised timeframe, that we had to adopt a flexible set of goals, one that could change as the project progressed, and most importantly, we wanted to empower the participants by providing them with tools that they could use in the future.

4. Objectives

Considering the design vector of the program, the project's main goal was to empower Timorese artists to create self-sustaining art-based products along with a strong personal brand. To achive this objectives, there was a reframing of the project's scope to include a toolkit for ongoing training and business development. With this, we sought to strengthen equity and democratic access to the experience, while creating a lasting impact in the community. As a means to communicate the results of this experience, and opening the project to the community, while reinforcing the sense of authorship, there was also the goal of creating a final exhibition and documentation of the project. As external designers, our main objective was to adopt and implement a participatory methodology grounded in dialogic and horizontal collaboration, evaluating each step through the lens of co-creation.

5. Design journey and outcomes

The project adopted a hybrid and iterative method, grounded in practice-based and participatory methods, informed by Sanders & Stappers (2008) and Mazzarotto (2024) within Freire's (2020) conception of critical dialogue.

The ten participants were mainly young artists though only three of them were women, which reflects the lack of visibility women have in the arts in this community. Among the group was one older participant, a senior artist well-known across various creative fields, including sculpture, music, performance and theatre. This was a pivotal figure around whom everyone gathered with respect. He was also a former guerrilla fighter with a remarkable life experience.

In the first stage, we focused on getting to know the community of artists. This was possible through online webminars, which included input theoretical sessions, practical exercises and more informal conversations. This was mediated by a tétum-portuguese translator and facilitated by the EU delegation in Dili that provided the technological infrastructure and space for the group to meet. This phase was long and challenging to manage due to communication barriers (such as internet connection and language). Regarding the language, although Portuguese is one of the official languages of Timor-Leste, it is not the primary language for this group of artists. This presented a new barrier: the lexicon, and there were, sometimes, concepts and ideas lost in translation, in both directions. Additionally, the designers struggled with understanding the expected pace and level of engagement from the participants. But slowly, mutual trust began to develop as the artists started to take ownership of designing the program path themselves. Through practical exercises that explored their background and own artistic practice and world-view, we developed discussion sessions that allowed the designers to better understand the reality. The main outcome of these first online sessions was the collaborative draft of a working plan for the onsite workshop week in Dili where we could identify the main topics that the artists wanted to research. Regarding the framing of the outcomes, we discussed both possibilities: individual and collective products. As for the main topics they selected "Moris" (Life); "Natureza" (Nature) and "Fantázia" (Fantasy).

Stage two was the face-to-face workshop, from July 21 to 25, 2025, in Dili, where the workshop was led by one designer. The sessions included some pre-recorded lectures from the European Brand and Market expert, but most of the work was around the product design process and visual identity.

[*] A free translation by the authors using the ChatGPT language model based on the original Portuguese text.

The first exercises implemented were classic creative ice-breakers. The first was a *cadavre-exquis*. Considering the strong relation to Nature and the territory, the prompt was to design a part of an animal, whether real or imaginary. This resulted in three creatures, that the group decided to name. One of the creatures became the metaphor of the project: *Kokoroek*. This is a Tetum onomatopoeia for the sound of a rooster. The rooster is one of the most common animals in the area and relates to the country's name and origin, Loro Sa'e, meaning "rising sun," as it is the animal that sings at the dawn.

The second was a visual mind map. This exercise was decisive for all the participants, artists and designer. Starting from the three keywords they had previously identified (Life, Nature, Fantasy), the artists started to add words and images. They linked projections of their individual worlds and slowly drew a visual conversation. During this process words, illustrations, objects and photographs were added to this collective mural. The senior artist played a key role in creating connections and narratives around the concepts that emerged on the paper. After some discussion, the artists started to identify some possible paths for their practical work, focusing on the development of products. They agreed on a collective approach, named *Kokoroek*, while still allowing for individual expressions.

The following days included input sessions on basic graphic design concepts and digital tools, as the artists were requesting specific resources to leverage their initial concepts. The ideation process was feed with local materials research and field trips. Alongside, there were parallel events related to music and culture, to which the designer was also invited. This allowed for a better and deeper understanding of their creative process and how they could develop their products in a sustainable way.

They quickly started prototyping on day two, experimenting with different techniques, both analogue and digital, as there was a computer available for them to work with. From lino printing to molding, weaving and drawing, they started designing products, inspired by their art and strongly grounded in the territory and heritage. During the workshop week, nine different products emerged, from which eight were further developed in the following months with ongoing supervision from the designers (Figure 1).

Seven of the participants took a questionnaire that allowed us to assess some of the impact of this activity.

Table 1. Workshop evaluation form.

Score 1 to 5	**1**	**2**	**3**	**4**	**5**
Overall impression	0	0	0	3	4
Format of the event	0	0	0	5	2
Duration of the event	0	0	1	4	2
Facilitation and moderation	0	0	1	2	4
Presentations/lectures	0	0	0	2	5
Group exercises	0	0	0	1	6
Practical exercises	0	0	0	3	4
Field visits	0	0	0	1	6

The results were quite encouraging (Table 1), with the vast majority of respondents providing combined scores of 4 and 5. The lowest-rated parameter was the duration of the event; however, it remained positive, with four participants assigning it a score of 4. The evaluation form included some qualitative questions, and some of the comments from participants were as follows: "We learned a lot in five days by working in groups."; "I gained new knowledge that taught me how to share my art with the world."; "All very good! I hope we can continue these kinds of activities in the future so that we can further develop our skills".

After the workshop, it was decided that one of the main contributions of this project could be the open access to all the materials and tools that had been created and delivered since the beginning of the program. This became a toolkit that was later handed-over to the Arte Moris association, as mediators for the Timorese arts community. The toolkit was specifically developed for this community, in both Tétum and English, to help them find ways to strengthen their capacity to present their work both online and offline. The modules included: Identity development; Market opportunities; Promotion and Communication; Product Development.

The final stage of the project included an exhibition of the results of the workshop. This happened at the Jorge Sampaio Cultural Centre, Portuguese Embassy in Dili in October 2025. The "Kokoroek – TIMOR-LESTE ART From Creative Practice to Cultural Product" was a co-curated exhibition that included a music performance by some of the artists, an art instalation, framing one of the products, and the display of the final prototypes.

The exhibition had great resonance in the cultural and political ecosystem of Dili, with the participation of many artists from the Dili art community, and H.E. President of Republic of Timor-Leste, Dr. José Ramos Horta, Ministers, Embassadors, along with high-level representatives from civil society.

Figure 1. Products.

6. Conclusions

Timor-Leste has a vibrant artistic community with a huge potential, that is only limited by socio-economic inequality. But this project concluded that a co-design approach may function as a tool to dissolve boundaries, towards a dialogic collaboration that fosters creative resilience and long-term competencies. Ultimately, the *Kororoek* brand emerged from shared authorship, incorporating local heritage, innovative ideas and technical know-how provided during the project. The toolkit documented design processes and business strategies, serving as an educational tool and knowledge repository hosted by *Arte Moris*, ensuring access to all Timorese artists. Participants reported increased capacity to communicate their work professionally and to develop independent artistic practices. Designers acted as facilitators, enabling environments for individual and authentic expression, while teaching and learning at the same time.

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GAMIFICATION FOR THE STREBER-APP – ENGAGING STUDENTS IN A MODERN COMPETENCE ORIENTED ASSESSMENT APP

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Abstract

Gamification—the integration of game-related elements into non-game contexts—offers a promising approach to increasing engagement and sustained use of digital learning applications. This paper presents the gamification-enhanced redesign of the Streber App, a mobile-optimised web application implementing the CREPS method (Create, Review, Enhance, Practice, Score), which supports competence-oriented learning through structured self- and peer-assessment. Originally developed in 2020 for a media technology university course, the Streber App has since been deployed across multiple courses and used by approximately 700 students. Within the app, learners create, refine, and evaluate multiple-choice questions based on course content. Peer evaluation focuses on quality, correctness, and complexity, while high-quality contributions are selected for further practice. Each phase of the CREPS workflow is incentivised through a points-based reward system, encouraging active participation and reflective engagement. A prior quantitative evaluation demonstrated strong overall acceptance of both the method and the application but also revealed concerns regarding long-term user engagement. Interestingly, a global high-score leaderboard—although pedagogically peripheral—was consistently identified by students as a motivating feature. In response, additional gamification elements were introduced, including user levels and a weekly resetting high-score system, with the aim of fostering sustained motivation and enjoyment of use. The enhanced application was translated into English and Slovak and piloted in a plant physiology course in Slovakia. Usage data indicated distinct participation patterns, ranging from students who substantially exceeded the workload required for course completion to those who engaged only at a minimum level. Findings indicate that the added gamification features positively influence student motivation and engagement, even though only a minority of learners are willing to invest effort beyond formal course requirements. The results highlight the potential of targeted gamification to support long-term engagement in competence-oriented digital assessment environments.

Keywords: *CREPS, Streber-App, gamification, peer assessment, mLearning.*

1. Introduction

The rapid scientific and technological transformation of recent decades has significantly influenced education, with artificial intelligence (AI) emerging as a key driver of change across learning environments (Al Farsi et al., 2024; Cukurova & Kent, 2019; Munir et al., 2022). These developments intensify the need for innovative teaching models capable of addressing growing knowledge demands while effectively leveraging digital technologies. At the same time, the integration of new technologies into education continues to present recurring pedagogical and organizational challenges (Moya & Camacho, 2024).

Higher education is therefore increasingly expected to move beyond knowledge transmission toward competence-oriented learning that fosters self-regulation, evaluative judgment, and sustained engagement. Digital and mobile learning environments are frequently viewed as enablers of such learner-centred approaches, offering flexible access to educational activities and supporting continuous interaction with learning content (Szymkowiak et al., 2021; Adams Becker et al., 2017; Uther, 2019). Mobile learning, understood as learning facilitated anytime and anywhere through evolving educational technologies, has consequently become a central pedagogical paradigm in contemporary education (McQuiggan et al., 2015; Schmiedl & Schmiedl, 2022).

Within these environments, long-term adoption depends not only on technical functionality but also on students' motivation, perceived usefulness, and willingness to engage continuously with the

system (Wang et al., 2024). Gamification—the integration of game-design elements such as points, rankings, levels, and feedback into non-game contexts—has therefore gained attention as a strategy to enhance engagement and enjoyment in digital learning, particularly among Generation Z students who favour flexible, interactive, and mobile-first learning experiences (Szymkowiak et al., 2021). Closely related, structured peer assessment supports competence-oriented education by promoting reflection, feedback literacy, and self-efficacy, provided that it is embedded in appropriate digital learning designs (Wang et al., 2024).

To address these pedagogical and motivational challenges, the CREPS method (Create, Review, Enhance, Practice, Score) was developed as a cyclical framework combining active knowledge construction, peer feedback, and iterative practice within scalable course settings (Schmiedl & Schmiedl, 2020; 2022). The Streber App operationalizes this approach as a mobile-optimised web application that enables students to generate, evaluate, and refine multiple-choice questions while engaging in continuous peer-supported learning. Previous evaluations demonstrated high acceptance and perceived effectiveness of both the method and the application, yet also indicated the importance of sustained motivation for long-term use.

This study investigates whether the integration of additional gamification elements in the Streber App increases student motivation, engagement, and sustained participation in a competence-oriented mobile learning environment. Against this background, the present study investigates the impact of additional gamification elements within the Streber App on student motivation and engagement in a competence-oriented mobile learning environment.

2. Methods

2.1. CREPS method and Streber app

The CREPS approach comprising the phases *create*, *review*, *enhance*, *practice*, and *score* was developed in early 2020 (Schmiedl and Schmiedl 2020). It provides a structured framework suitable for teaching groups of any size, without placing a substantial additional workload on instructors. The method emphasizes self-assessment and peer evaluation, both of which are essential components of competence-oriented education. Its core principle is a cyclical process in which students design and progressively refine assessment questions derived from the course content. These questions are subsequently reviewed by peers, who evaluate them in terms of accuracy, quality, and level of difficulty. High-quality questions are then selected for continued practice activities. Throughout the process, students earn points for their contributions, with higher-quality questions and constructive feedback leading to increased scores.

To support innovative teaching, learning, and assessment practices within a competence-based educational context, the CREPS methodology was implemented through the Streber App (Schmiedl and Schmiedl 2022). This web-based application is particularly designed for use in large student cohorts and operationalizes the CREPS concept in a digital environment (see figure 1). Instructors can divide a course into multiple modules, set specific timeframes for the creation and practice phases, and allocate point values to various student activities such as question development and peer review. While the application is optimized for use on smartphones, it is fully functional across modern web browsers on desktop devices as well. A key advantage of the Streber App is its flexibility, enabling students to engage in learning activities independently of time and location. The method focuses on the student's learning success and their motivation as well as on the applicability of the method in university courses and the usability of the Streber app.

The Streber app and CREPS method were applied to student groups that study biology and ecology at the Faculty of Humanities and Natural Sciences, University of Prešov. The content was created based on the 10 lectures and practices within the study course *Plant physiology*. The final course grade was based on three criteria, with the results from using the Streber app accounting for one component and carrying the highest weighting (70%).

2.2. Questionnaire

At the end of the course, all 47 students were invited to complete a questionnaire about their semester-long work with the Streber app. A total of 41 students responded, corresponding to a response rate of 87%. The sample consisted of 29% male and 71% female students. The final grades of the students who participated in the survey were distributed as follows: A: 63%, B: 10%, C: 12%, and D: 15%.

The questionnaire comprised seven thematic sections with 36 sub-questions assessed using a Likert scale. A seven-point agreement scale was applied, ranging from *strongly disagree* (1) to *strongly agree* (7). In addition, two sections contained four open-ended questions with free-text responses.

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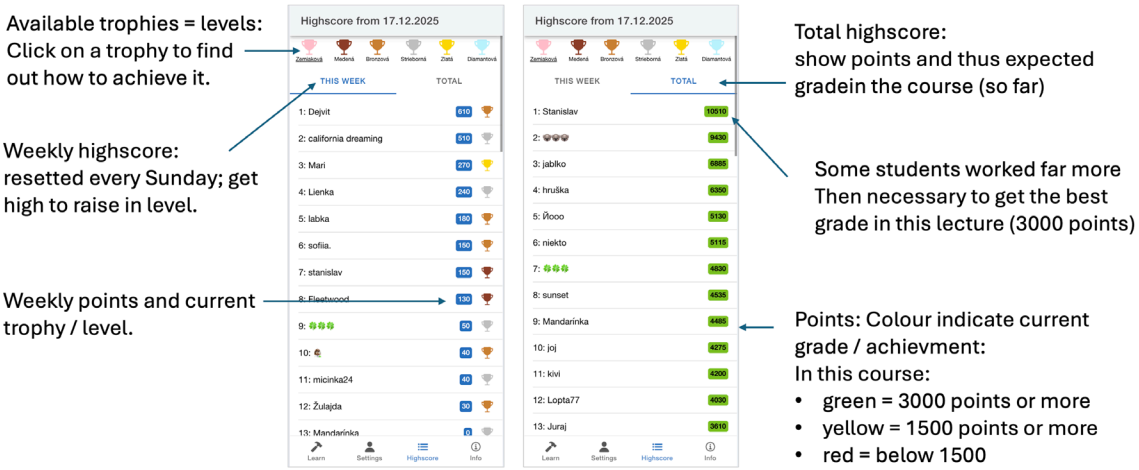
The Likert-scale sections covered the topics: Learning benefit (4 questions), Motivation through the method (5 questions), Extrinsic motivation (6 questions), Motivation for long-term use (6 questions), Barriers and demotivation (4 questions), Honesty-related aspects (8 questions) and Perceptions of the Streber app (3 questions).

Figure 1. Gamification in the Streber app: weekly/total highscore and levels=trophies.



3. Results and discussion

3.1. Perceived learning benefits

Students reported very strong perceived learning benefits from the Streber app. Across key learning-related items, the majority of responses clustered in the upper agreement range (6–7). For example, creating their own questions, repeated testing, and long-term engagement with the app all showed high proportions of strong agreement, frequently exceeding one third to nearly one half of responses. Only marginal disagreement was observed, indicating consistently positive learning perceptions.

Learning through reviewing peer-generated questions showed slightly lower—yet still distinctly positive—agreement levels, indicating that creating one's own content was perceived as more beneficial than evaluating others' work.

3.2. Motivation through the method CREPS and its implementation, the Streber-App

Motivational and feedback-related items also demonstrated predominantly positive agreement patterns. Most students reported that the app supported self-assessment and critical thinking, and both giving and receiving feedback were evaluated positively, with agreement responses clearly outweighing neutral or negative categories. Written feedback remained motivating even when critical, indicating constructive acceptance of peer evaluation.

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3.3. Gamification elements and motivational impact

The central aim of this study was to evaluate whether the gamification mechanisms embedded in the Streber app - namely points, overall rankings, weekly rankings, and trophy rewards - produced measurable motivational effects among students.

3.3.1. Awareness and behavioural engagement. Students demonstrated very high awareness (80% agreement level 6 and 7) that only accumulated points influenced formal course grading, while rankings and trophies had no direct academic consequences. Despite this explicit knowledge, gamified competition remained behaviourally relevant. Around 66% of respondents agreed (6–7) that they regularly checked their ranking position, and roughly 70% reported feeling motivated by their ranking visibility.

Active attempts to reach higher weekly rankings or better trophies were somewhat weaker but still notable, with about 50–55% indicating agreement. During the course, this became evident as several participants competed for first place in the high-score ranking, surpassing the total number of points required for a grade A by a substantial margin.

In contrast, only about 39% agreed that comparison with other students is irrelevant, while a similar proportion selected neutral or disagreement categories. This pattern suggests that social comparison retained meaningful motivational influence, even when not explicitly acknowledged.

Notably, students with lower overall course grades, and consequently lower high-score positions, reported significantly more often that their ranking was irrelevant.

3.3.2. Sustained motivation and competitive dynamics. Long-term engagement indicators were strongly positive. Approximately 73–83% of students agreed (6–7) that the app helped them stay engaged throughout the semester and should be used in future subjects.

At the same time, boredom or purely grade-driven usage showed markedly lower agreement, with only about 15–20% selecting agreement levels, while the majority responded neutrally or negatively.

This indicates that engagement was not dominated by extrinsic pressure alone but instead reflects a hybrid motivational structure combining competitive extrinsic cues with intrinsic learning engagement.

3.3.3. Negative competitive effects. Potential negative consequences of leaderboard-based gamification were minimal. Only about 5–10% of students agreed that low ranking positions discouraged them or visibility of weak performance was demotivating.

In the Streber-App students were given the possibility to opt out of appearing in the high-score list; however, this would also have prevented them from viewing the ranking (an all-or-nothing configuration). None of the participants chose to opt out.

Thus, competitive visibility rarely produced negative emotional responses, contradicting common concerns in leaderboard-based gamification literature.

4. Conclusion

This study examined the motivational and learning-related effects of gamified peer-assessment within the CREPS-based Streber learning environment. The findings indicate that integrating gamification elements such as points, rankings, and progress indicators can positively support student engagement and sustained participation in competence-oriented assessment activities. Students reported clear short-term motivational benefits alongside continued interaction with course content over the semester.

At the same time, the results suggest that gamification functions most effectively as a supportive scaffold rather than a substitute for intrinsic motivation. The perceived learning advantage of self-generated questions over merely reviewing peer content further highlights the importance of constructive, active participation in digital learning processes.

Overall, thoughtfully aligned gamification can enhance engagement in mobile competence-oriented learning environments, but its long-term educational value depends on maintaining coherence between reward structures, meaningful learning activities, and academic integrity.

4.1. Future work

Several aspects emerged that were only marginally addressed in this study but warrant systematic investigation in future research.

First, the growing availability of artificial intelligence tools raises important questions regarding their role in question generation and review processes. Future work should examine whether AI-assisted content creation enhances learning through scaffolding and feedback or risks reducing meaningful cognitive engagement by outsourcing core learning activities.

Second, mechanisms for reviewing peer-generated questions require closer scrutiny. The current system allows superficial interaction or automated responses to gain points without genuine effort, highlighting the broader challenge of ensuring honesty and authentic participation in gamified assessment environments.

Future research should therefore explore technical, pedagogical, and ethical strategies to mitigate dishonest behavior, including improved detection of automated interaction, reward structures privileging depth over quantity, integration of reflective components that are harder to automate, and explicit promotion of academic integrity within gamified systems.

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HOW YOUNG BILINGUALS TRANSLATE STORIES: A STUDY OF LEXICAL EQUIVALENCE AND EXPRESSIVE STRATEGIES

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Abstract

This study investigates the skill of natural translation in one early bilingual respondent acquiring Spanish and Slovak simultaneously. The research focuses on lexical equivalence, semantic shifts, and the expressive value of selected lexical items in the target language during spontaneous narrative retellings. The data were collected over a 12-month period through three elicitation sessions, in which the respondent first narrated a picture-based story in Slovak and subsequently translated it into Spanish without access to the original Slovak text. All recordings were transcribed using the CHILDES system and processed through qualitative analysis based on Miko's system of expression and Popovič's communicative model of translation. The aim of the study is to examine how young bilinguals preserve or modify the expressive value of lexical items, how they choose equivalents in the target language, and what compensatory strategies they use when lexical retrieval becomes challenging. Special attention is paid to code-switching, semantic approximation, circumlocution, and the creative reconstruction of narrative elements.

Keywords: *Bilingual children, natural translation, narrative retellings, lexical equivalence, communicative model of translation.*

1. Introduction

Early bilingualism provides a privileged context for observing the emergence of translation competence, as children who acquire two languages simultaneously often mediate between them spontaneously, without formal training. This phenomenon, commonly referred to as natural translation, represents an intuitive, meaning-oriented activity in which bilingual speakers transfer content across languages under real-time cognitive and lexical constraints (Harris 1976, Harris & Sherwood 1978, Álvarez de la Fuente & Fernández Fuertes 2012, Álvarez de la Fuente & Fernández Fuertes 2015, Fernández Fuertes & Álvarez de la Fuente 2017, Álvarez de la Fuente, Fernández Fuertes & Arratia García 2019, Álvarez de la Fuente & Fernández Fuertes 2025, Hornáčková Klapicová 2021a, Hornáčková Klapicová 2021b, Ciprianová & Hornáčková Klapicová 2024). In child bilingualism, natural translation prioritizes communicative adequacy and narrative coherence rather than formal or lexical correspondence.

From a translation-studies perspective, children's natural translation can be productively interpreted through Popovič's (1983) communicative model of translation, which conceptualizes translation as purposeful interlingual communication rather than mechanical equivalence transfer. Within this framework, shifts, approximations, omissions, and restructuring are not viewed as deficiencies but as legitimate outcomes of adaptive meaning transfer (Ciprianová & Hornáčková Klapicová 2024, Paradis 2007, Álvarez de la Fuente & Fernández Fuertes 2015, Álvarez de la Fuente & Fernández Fuertes 2017, Hornáčková Klapicová 2021a, Hornáčková Klapicová 2021b). When direct lexical equivalence is unavailable, bilingual children preserve communicative intent by employing compensatory strategies, including semantic approximation, generalization, circumlocution, omission, and code-switching (Ciprianová & Hornáčková Klapicová 2024, Patterson & Pearson 2004, Nicoladis 2019, Bialystok 2011, Bialystok 2017).

An additional dimension of natural translation concerns the transfer of expressive value, understood as the emotional, stylistic, or evaluative coloring of lexical items. Here, Miko's (1968 & 1989) system of expression provides a suitable analytical framework for identifying how expressive value is preserved, attenuated, or neutralized in translation. Because expressive marking is closely linked to language dominance, input frequency, and pragmatic routines, expressive value may be robust in one

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language while being reduced or absent in the other, even when denotative meaning is successfully transferred.

The present study examines natural translation between Slovak and Spanish in an early bilingual girl through picture-based narrative retellings followed by self-translation. Using qualitative analysis grounded in Popovič's (1975 & 1983) and Miko's (1968 & 1989) frameworks, the study addresses three interrelated research questions: (1) how early bilingual children establish lexical equivalence in natural translation, (2) to what extent expressive value is preserved or modified in the translation process, and (3) which compensatory strategies are employed when lexical retrieval becomes constrained. By approaching child translation as a communicative and functional activity, this study contributes to a translation-studies-oriented understanding of bilingual lexical development and early translation behavior.

2. Participant selection and research methodology

The respondent was selected according to criteria related to bilingual competence, i.e. demonstrating functional proficiency in Slovak and Spanish. To ensure comparability of linguistic exposure, the respondent spent time in Slovakia during the research period.

Data collection was based on narrative and translation tasks using wordless picture stories, thereby limiting the influence of written language input. Data were collected over a 12-month period through three elicitation sessions. In each session, the respondent first narrated a story based on visual stimuli in Slovak (source language) and subsequently translated her own narration into Spanish (target language) without access to the original Slovak version.

All recordings were transcribed in the CHILDES/CHAT format and analyzed qualitatively. Translation shifts and meaning transfer were interpreted through Popovič's communicative model, while changes in expressive value were examined using Miko's system of expression. Lexical gaps and deviations were treated as indicators of compensatory strategies rather than as translation errors.

3. Results

Respondent 1 was an early bilingual acquiring Slovak and Spanish simultaneously and was 7;07 (7 years and 7 months) old at the onset of the study. Her father addressed her in Spanish and her mother in Slovak. She attended a Slovak-speaking elementary school in Slovakia and received Spanish input primarily from her father and paternal family members. Her natural translation competence showed stable meaning transfer with occasional semantic shifts and creative reconstruction when lexical retrieval became constrained.

Example 1. Respondent 1 at 7;07 years.

@Begin	
@Languages:	slk, esp
@Participants:	RE1 Respondent 1, Target_Child, RES Researcher
@Situation:	Respondent 1 is retelling a story about a little elephant
*RE1:	že sloník bol smutný a prišiel za ním slimák a (.) priniesol mu darček, loptu@slk
%eng:	that the little elephant was sad and a snail came to him and brought him a gift, a ball
*RE1:	el elefante está triste y el caracol viene y le da un regalo, la pelota@esp
%eng:	the elephant is sad and the snail comes and gives him a gift, the ball
@End	

Example 1 shows that semantic and formal equivalence are preserved through direct lexical equivalence (e.g., 'slimák' → 'caracol'). However, when lexical retrieval became difficult, Respondent 1 employed compensatory strategies.

Example 2. Respondent 1 at 7;07 years

@Begin	
@Languages:	slk, esp
@Participants:	RE1 Respondent 1, Target_Child, RES Researcher
@Situation:	Respondent 1 is retelling the story of The Gigantic Turnip

*RE1: prišla myš, ona mu dala pastelku@slk
%eng: a mouse came, she gave him a crayon
*RE1: después viene un ratón y da da el regalo un (...)@esp
%eng: then a mouse comes and gives gives the gift a
*RES: si no sabes el nombre del objeto, puedes decir algo similar (..)@esp
%eng: if you don't know the name of the object, you can say something similar
*RE1: color?
%eng: color?
@End

In Example 2, the lexical item 'pastelka' ('crayon') triggers semantic approximation: Respondent 1 produces the broader target-language label 'color' when she cannot retrieve the more specific equivalent. Across sessions, equivalence selection shows variability, which is typical of developing natural translation competence under repeated elicitation.

Table 1. Respondent 1 lexical equivalence selections across sessions.

First elicitation session		Second elicitation session		Third elicitation session	
Slovak	Spanish	Slovak	Spanish	Slovak	Spanish
pastelka (crayon)	color (color)	farbička (color)	lápiz (pencil)	farbička (color)	color (color)

Respondent 1 also substituted unknown words with conceptually related items. She substituted the Slovak work "repa" ("turnip", "beetroot") with "zanahoria" ("carrot") in Spanish. Functional equivalence was preserved, as she used the name of a different type of vegetable, but the denotative meaning was shifted. This reflects a semantic approximation strategy, typical in child bilinguals. At the same time, this can be interpreted as a form of generalization, since only a broader category of the object was expressed.

The expressive value of words was preserved mainly in Respondent 1's responses in Slovak as she was frequently using diminutives. In total she used 10 words in Slovak with added emotional and expressive coloring. No expressive words in Spanish were recorded, which indicates that the Respondent 1's communication in Spanish was more neutral and her vocabulary span was more limited.

Certain frequently repeating connectors were recorded, which resulted in high redundancy. Respondent 1 repeated the Slovak word "potom" ("then", "afterwards") 25 times and its Spanish equivalent "después" ("then", "afterwards") 26 times. Respondent 1 applied the same discourse strategy using this pattern in both languages.

We also recorded several types of compensatory strategies. Respondent 1 tended to use omission when she was uncertain how to translate a particular part of the story. We did not record any instances of code-switching, which might be due to the respondent's older age or a preference for omission over code-switching. In Spanish in particular, she showed a tendency toward implicitness rather than explicitness. In the first elicitation session Respondent 1 finished one of the stories in Spanish implicitly as "y ya está" ("and that is it"), even though in Slovak she said "a mali svadbu" ("and they had a wedding"). Maybe she was lacking the vocabulary and relied on the comprehensibility of her translation despite not finishing it properly. Over the time, Respondent 1 was more explicit in both languages; however, her language proficiency in Slovak was higher.

In Table 1, the first respondent decided to use lexical approximation instead of omission, when she could not retrieve the proper lexical equivalent. She chose the strategy of lexical approximation with the word "crayon", which she named "color" or "pencil". The same strategy was used in the story of "The enormous turnip". During the first elicitation session, she called the turnip "repa" ("turnip") in Slovak but she translated it into Spanish as "zanahoria" ("carrot"). She preserved the semantic category of the vegetable, but it was not the accurate lexical equivalent (co-hyponym). The same strategy was used during the second elicitation session. In the last session, Respondent 1 used the appropriate equivalent in Spanish "remolacha" ("beetroot"). Even though it might appear as if she did not translate the word "turnip" correctly, there is a reason for it, since the Spanish story uses beetroot as the vegetable that cannot be pulled from the ground.

During the second elicitation session, Respondent 1's narratives became more elaborate; however, during the third elicitation session Respondent 1 started the story the same as when she was younger. It did not reveal her language progress over the time, because during the third elicitation session she omitted one part of the beginning of the story in Spanish.

Table 2. Respondent 1 narrative openings across sessions.

First elicitation session		Second elicitation session		Third elicitation session	
Slovak	Spanish	Slovak	Spanish	Slovak	Spanish
že sloník bol smutný (that the little elephant was sad)	el elefante está triste (the elephant is sad)	Slon bol smutný, lebo si myslel, že všetci zabudli na svoje narodeniny. (The elephant was sad because he thought that everyone had forgotten their birthday.)	El elefante está triste porque cree que se ha olvidado de su fiesta. (The elephant is sad because he thinks that his party has been forgotten.)	tak slon bol smutný, a niekto zazvonil na dvore, išiel na dvere, išiel sa pozrieť. (So the elephant was sad, and someone rang in the yard; he went to the door to see.)	el elefante está triste (the elephant is sad)

Overall, Respondent 1's output indicates that natural translation in early bilinguals is an intuitive, meaning-oriented process. She typically preserved core meaning, compensated for lexical gaps, and when necessary reconstructed narrative elements using compensatory strategies. With respect to expressive value, Slovak diminutives and expressive items were present in the source-language narratives, whereas expressive value was largely neutralized in the Spanish target-language renditions.

4. Responses to research questions

4.1. How do early bilingual children establish lexical equivalence when translating from Slovak to Spanish?

The respondent attempted to establish lexical equivalence through direct target-language selection when an accessible equivalent was available. When direct equivalence was not achievable, she relied on compensatory strategies. Respondent 1 more frequently maintained internal narrative coherence through semantic approximation or omission, instead of code-switching or explicit requests for assistance.

4.2. To what extent is the expressive value of lexical items preserved, modified, or neutralized in the process of translation?

Across the sessions, expressive value was robust in Slovak narratives, particularly through diminutives and affectively marked lexical items, yet it was largely neutralized in Spanish target-language renditions. Even when denotative meaning was preserved, expressive value was not systematically transferred, indicating that expressive marking was language-dependent and sensitive to dominance and pragmatic entrenchment.

4.3. What compensatory strategies are employed when children are unable to retrieve an appropriate lexical item?

When lexical retrieval constrained target-language production, the child employed compensatory strategies, including semantic approximation, generalization and omission. The respondent tended toward internal reconstruction, whereas she could rely on code-switching or interactive scaffolding.

5. Conclusion

Overall, the study confirms that early bilingual children are capable of natural translation that is meaning-oriented, flexible, and strategy-driven. Language experience influence lexical precision, expressive value transfer, and compensatory behavior. While expressive value is typically preserved in the stronger language, it is often neutralized in target-language renditions. The respondent, likely due to her higher age, did not rely on code-switching or external support and tended to reconstruct meaning internally. These findings contribute to understanding within translation studies of bilingual lexical development, metalinguistic awareness, and the cognitive processes underlying natural translation in young bilinguals.

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THE IMAGE OF SCHOOL AT THE INTERSECTION OF THEORY AND PRACTICE IN THE DISCOURSE OF FUTURE TEACHERS

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Abstract

The aim of this presentation is to present selected findings from the two-year project Flying School of Teaching Practicum, carried out within the Science for Society programme at the Maria Grzegorzewska University in Warsaw. The project was research-and-application oriented. It involved the implementation of teaching practicum by students—future early childhood education teachers—under the supervision of academic staff in intentionally selected primary schools distinguished by their organizational, methodological, or curricular approaches. The study aimed to analyse the experiences students gained in the professional environment. The method used was participatory action research (Kemmis & McTaggart, 2005), and the research material was collected through eight focus group interviews with students participating in the project and through their reflective journals (134 in total). The analysis shows a gap between the image of modern school education constructed within the university and the realities of everyday school practice. This gap becomes visible in the areas of the organization of the teaching and learning process, the methods and forms of work used, and the way the roles of teacher and pupil are perceived. In students' statements, on the one hand, there appears fascination with innovative solutions implemented in selected schools, such as group work, project-based learning, or an emphasis on socio-emotional competencies; on the other hand, there appears a sense of helplessness in the face of entrenched organizational schemes, time pressure, the dominance of textbooks, and standard forms of work that make it difficult to implement modern teaching approaches.

Keywords: *University-school partnership, student internships, reflective practice.*

1. Introduction

Contemporary school functions in conditions of dynamic social, civilizational, cultural, technological, and economic change, which redefine its traditional functions and the organization of teaching and educational processes. Globalization, digitalization, cultural diversity, and growing expectations regarding the quality of education make it impossible to limit schooling to the transmission of knowledge. School has lost its monopoly over knowledge transfer, as a result of complex social, technological, and cultural processes that have transformed the ways children participate in the world of information. Educational practice still too rarely recognizes and uses the potential of pupils' cognitive autonomy, perpetuating transmissive didactics based on knowledge reproduction (Bałachowicz, 2009; Klus-Stańska, 2018). That is why it is so important to develop an educational environment based on flexibility, transdisciplinarity, collaboration, and reflection (Bruton, 2011).

These changes imply the need to redefine teacher education toward the development of creative and reflective thinking about education. Teacher education can effectively support the development of a reflective and critical attitude toward educational practice, which helps prepare future teachers for conscious action based on the appropriate use of pedagogical knowledge. Such an attitude enables them to critically analyse their own experiences, adapt to changing educational conditions, and make educational decisions based on careful evaluation and deeper reflection (Perkowska-Klejman, 2015). In this context, the development of the teacher as a creative and reflective professional is particularly important (Schön, 1983), for whom partnership, dialogue, and systematic reflection on practice are key principles of action. Among pedagogy students, these attitudes can be developed primarily in the school environment, through cooperation between the university and schools. During these experiences, students have the opportunity to confront the theoretical assumptions learned during their studies with the possibilities and barriers to their implementation in the world of school practice. In this text, we make this confrontation the central point of our reflection. We attempt to answer the question: What image of modern education is constructed

within the university, and does it find reflection in everyday practice—with particular emphasis on teaching practicum carried out within school-university partnerships?

2. Methods

The study was designed as participatory action research (Kemmis & McTaggart, 2005; Heck, 2024), aimed at solving organizational problems through the involvement of those who experience them (Herr & Anderson, 2015). The aim of the study was to improve the quality of teaching practicum by developing and implementing a practicum model in cooperation with students—future early childhood education teachers—and intentionally selected public and non-public primary schools in Poland, within the so-called concept of "university-school partnerships" (Day, 2006), in order to create a learning community (Smith & MacGregor, 2009) and promote learning through reflective practice (Schön, 1983).

The analysis forms part of broader research carried out within the project Flying School of Teaching Practicum* (Koterwas et al., 2024). The research was conducted from February 2024 to March 2026. It included 134 students of preschool and early childhood pedagogy at the Maria Grzegorzewska University in Warsaw, who had the opportunity to complete a one-week practicum in "model" schools distinguished by the active work of principals or founders, their distinctive curricula, or the organization of education based on constructivist assumptions. Immediately after completing their one-week practicum within the project, eight focus group interviews were conducted. The transcripts of these interviews were subjected to inductive thematic analysis (Braun & Clarke, 2006) using open coding. The study received a positive opinion from the Senate Committee for Research Ethics at APS. In this article, we analyse material concerning students' confrontation of professional academic knowledge with school praxis. We ask what vision of modern education is outlined by future early childhood education teachers and whether it is reflected in everyday pedagogical practice.

3. Discussion and conclusion

3.1. The image of modern school

During the focus group interviews, students participating in the Flying School of Teaching Practicum project confronted academic knowledge with their own experiences from practicum placements in schools intentionally selected for the project. They constructed high expectations of school based on an idealized vision shaped by the pedagogical knowledge acquired during their studies. They paid particular attention to the need for pupils' cognitive activation as a condition for learning. "Here at the university we are often told to arrange the desks somehow in groups or in horseshoes, in an active way. And going on practicum, I wanted to see that" (FGI3). In their statements, characteristic expressions appeared, indicating the belief built up during their studies in the existence of only one correct model of the ideal school: "I expected novelty and innovation and wanted to see this ideal theory in practice" (FGI3); "I had very high expectations because it was a great project, an innovative school, and I went there thinking it would be amazing, something 'wow'!" The modern school is thus framed as something extraordinary, alternative, fascinating, with a "wow" effect. Students presented this image mainly in opposition to the traditional school model, by negation rather than by describing its specific functioning. "We could see a different way of working, compared to my earlier practicum, where there was literally a coursebook, a workbook and you just do everything from A to Z" (FGI2). "I went [to the practicum] wanting to change how I perceive school, to see how it can look different" (FGI1).

Among some students, the ideal school vision constructed during pedagogical studies was described as "strange" or unrealistic to implement in practice: "Here [at the university] they sometimes tell us to do different strange activities and try them, and I sometimes cannot imagine how one could conduct that in school and still manage to do everything and engage everyone" (FGI3). The theoretical construct of the ideal school is perceived by students as "strange" when it goes too far beyond their imagination of school and beyond the biographically entrenched model they have accepted. This gap between the image of modern school outlined at the university and the hierarchical, formal, and predictable school reality creates in them a sense of uncertainty, but also curiosity and a desire to test the extent to which the ideas learned during their studies can actually be used in everyday practice. In this way, practical experience becomes a space in which their entrenched schemes of perceiving school are confronted with new, more creative possibilities for teachers' action. Activities involving the organization of space or the inclusion of pupils in lesson delivery—which seem "strange" or difficult to realize during university classes—take on new meaning when, despite the difficulties, they are attempted in school practice. As a result, the ideal

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model of school is not rejected, but gradually transformed into a more realistic and reflective one, adapted to specific conditions, an image of school in which learning means not only acquiring knowledge "about" reality, but also "in" reality and "through" reality.

3.2. School praxis

After study visits to intentionally selected schools within the Flying School of Teaching Practicum project, some students noticed a reflection of academic knowledge in school practice. They referred to specific lesson observations: "In mathematics classes in first grade I noticed that the practical classes were almost one-to-one the same as those we have at the university with the doctor, and I could observe what it really looks like in practice with children. (...) it was clear that what we are learning here really transfers to what happens later in class" (FGI7).

Today, the teacher should become a co-creator of a dynamic educational environment in which children are supported in learning not only about reality, but also within it and through experiencing it (Maynard, 2001). Students described these experiences as highly valuable, emphasizing that lessons in the selected schools revealed concrete implementation of the methods and forms of work they had learned at the university. They pointed out that they could observe how pedagogical theory "works" in everyday classroom activity, which strengthened their belief in the usefulness of their studies and showed the real transferability of academic knowledge into educational practice (Heintz, 2024). The encounter between theory and pedagogical practice is described in the literature as a key moment in the development of the reflective teacher (Schön, 1983; Zeichner & Liston, 2013; Loughran, 2010; Bernay et al., 2020). "I finally saw that it is possible (...) and that you can organize the teaching process in such a way as to introduce these interesting, diverse methods into practice" (FGI4). Such experiences are crucial for the development of professional pedagogical knowledge, because they allow students to see that innovative methods and forms of work are not merely a student abstraction, but a real and functioning part of school praxis. They sustain motivation for experimentation, strengthen a sense of didactic competence, and build the conviction that school can be a space for active, creative, and reflective learning. Thus, the professional pedagogical knowledge being formed ceases to be "dry theory" that is impossible to apply in the school environment.

Some students had different experiences. They reported that they observed lesson organization consistent with their vision of a "model" school only in individual teachers. Students said: "There are no such nice, innovative, ideal schools, but there are teachers who try…" (FGI5). This observation gave them a sense of agency in the role of teacher-innovator: "Even if the school is not especially conducive, I can do it in my own way too, and then it's like, okay, it can be done, I'll do it" (FGI4). Observing even one such teacher during students' educational biographies is crucial for the construction of their professional identity. These practicum experiences not only helped to overcome negative experiences from earlier placements, but also inspired further action: independent observations, entering the teaching profession, and planning their own projects. Students strengthened their sense of competence: "I was in one lesson with a first-grade teacher and really one hour was enough for me to understand what it is about. What it could look like and what it should look like. I was thrilled (...) I saw so much to draw from that it will definitely stay with me for a long time" (FGI1).

Despite the careful selection of schools for our project, some students were disappointed by the lessons they observed. They emphasized that these lessons diverged from academic knowledge. "We learn all these amazing things, and then we go there and they sit all day doing workbooks—where is all that we are learning?" (FGI2). "The practicum itself differs, in my opinion, from what they feed us here. Because they feed us cotton candy, some ice cream. I mean, do this, do that, be like this. Constantly, constantly something. It is very different" (FGI3). These metaphors ("cotton candy," "ice cream") convey the perception of the university as a place of illusory, ephemeral ideals that contrast with school everyday life. In this way, the felt gap between the modern, creative vision of school conveyed at the university and the traditional, bureaucratic school practice becomes a signal to students that teacher education requires better integration of reflection on real school conditions and dialogue between the university and the school environment. Only such dialogue can contribute to a more coherent and realistic image of school in which theory and educational practice complement one another.

4. Conclusion

The analysis reveals a fundamental gap between the idealistic vision of school built within the university as a space of innovation and activation, and school praxis, which often perpetuates traditional transmissive patterns dominated by workbooks and pupil passivity. This contrast appears both in students' narratives expressing fascination with "modern" theoretical proposals and in frustration caused by their absence in practice. The statements about university "cotton candy" versus the "ordinary" school indicate

that pedagogical knowledge conveyed during studies remains, for many students, isolated from the real conditions of everyday school life, making it difficult to translate into practice.

As a result, the gap between theory and practice becomes an important signal for teacher education, pointing to the need for a reflective linking of theory with school realities, where students can analyse the limitations that emerge. Only then can practical experience contribute to building a more realistic and flexible image of school as a space of learning for both pupils and future teachers, while beginning to function as a "catalyst for reflection," encompassing not only criticism of school realities but also verification of students' assumptions. Students gradually come to the conclusion that the "ideal" school does not exist as a ready-made, universal model, but emerges through continuous experience, experimentation, and dialogue between theory and everyday practice (Goldshaft, 2024). Teaching practicum becomes for them a space where theory meets reality (Loughran, 1996; Zeichner & Liston, 2013), and the image of the modern school shifts from a "wow" stereotype toward a more realistic, reflective, and critical vision of school as a setting for life, learning, and co-creation.

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STAR WARS, JENGA AND SUSTAINABLE BUSINESS MODELS - EXPERIENCES AND FINDINGS FROM AN EU PROJECT ON USAGE OF GAME ELEMENTS IN ENTREPRENEURIAL EDUCATION

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Abstract

This article explores the implementation and effects of gamification in higher education through the G4C:NGE project. The curriculum, integrating 27 game elements and 49 game scenarios into three entrepreneurship modules, was piloted at seven European business schools, combining local and international formats and involving over 700 students. Evaluation results indicate that gamification enhances motivation, creativity, teamwork, and confidence. While gamification fosters essential skills for future entrepreneurs, challenges remain in aligning game elements with academic content and optimizing assessment. Recommendations include refining gamified methods and promoting intercultural exchange to further improve entrepreneurship education.

Keywords*: Playful learning, entrepreneurship, higher education, international project.*

1. Introduction

In recent years, gamification has become increasingly significant in higher education, as evidenced by steady growth in interest since 2010. Research indicates that game elements can enhance learning experiences and outcomes, with positive effects on student behaviour, performance, and satisfaction, especially when considering learner profiles (Khaldi et al., 2023). The impact of gamification depends on its implementation (Fischer & Rohr, 2014), supporting motivation, engagement, and performance in educational settings (Tolks & Sailer, 2021). Gamification also strengthens cognitive skills like problem-solving, creativity, and decision-making, which are essential *21st Century Skills* (Arnold et al. 2023; Csapó & Funke, 2017; Qian & Clark, 2016). This is where the project G4C:NGE comes in.

The overarching goal of the EU-Project *G4C:NGE* (Game4Change – Playful Learning in Next Generation Entrepreneurship) is to develop and provide content, training materials, strategies, guidelines, and best practices for gamification in business education. Additionally, a study program for Next Generation Entrepreneurship (NGE) is being developed to equip students at business schools across Europe – including Dresden University of Technology, Fachhochschule Dresden, DOBA Business School, WSB University, Rotterdam University of Applied Sciences, UC Leuven-Limburg University of Applied Sciences, and the international academic network BUSINET – with the necessary skills to tackle entrepreneurial challenges using playful methods (Fischer et al. 2024; Müller et al. 2024).

2. Curriculum design

The Next-Generation Entrepreneurship program consists of three modules, each worth 3 ECTS, which can be taken independently or combined into a comprehensive course. *Module 1, Ideation*, teaches students how to apply Design Thinking to develop innovative business ideas, with a focus on customer needs, creativity, and iterative improvement. *Module 2* focuses on designing s*ustainable business models*

that prioritize ecological and social responsibility, while students learn to create, test, and develop a business model along with a Minimum Viable Product (MVP). *Module 3* is dedicated to *leadership* in an international context, where students develop leadership skills, take responsibility for their own career, make ethical decisions, and gain intercultural competence. All modules emphasize teamwork, critical thinking, and the ability to overcome challenges.

The development of the curriculum is based on the didactic theory of constructive alignment and wants to achieve the following learning outcomes:

Module 1: Creating Innovative Business Ideas

- Understand and apply the ideation process in entrepreneurship.
- Utilize critical thinking to tackle challenges in ideation.
- Craft and convey a strong business idea and its value.
- Collaborate effectively in teams to brainstorm and refine business concepts.

Module 2: Sustainable and Impactful Business Modelling

- Identify and tap into potential markets.
- Design an innovative and sustainable business model.
- Evaluate and refine the business model based on insights.
- Develop a minimal viable product (MVP) for real-life testing or simulations.

Module 3: Impactful Leadership

- Define a vision and strategies for futureproof and responsible leadership.
- Take responsibility for one's own sustainable career path.
- Seek, receive, and assimilate feedback on personal objectives.

2.1. Gamification of course content

The integration of game-based learning strategies posed a major challenge for the G4C:NGE project, as the newly developed concepts always had to align with the academic content of the courses. At the outset, a total of 27 game elements were identified and described as foundational components for the course's gamified scenarios.

Table 1.

1. Achievement Tracking	10. Interactive Quizzes	19. Rewards
2. Avatars	11. Interactive Simulations	20. Role-Playing
3. Badges	12. Leader boards	21. Scenario-Based Learning
4. Bonus Points	13. Levels	22. Social Sharing
5. Challenges	14. Mentorship Programs	23. Storytelling
6. Learning Paths	15. Peer Reviews	24. Team-Based Activities
7. Easter Eggs	16. Points System	25. Time-Based Challenges
8. Feedback	17. Progress Bars	26. Unlockable Content
9. Interactive Maps	18. Quests	27. Virtual Currency

Building on this foundation, approximately 49 game-based scenarios were developed and tailored to the three course modules: Ideation, Business Modelling, and Leadership. Each scenario incorporated multiple game elements to create diverse learning experiences—ranging from collaborative challenges and creative problem-solving to competitive simulations. Following Table demonstrates the game-based scenarios of module 1.

Table 2.

Module 1	Creating Innovative Business ideas	Gamified elements
Introduction	Who are you? Building a low-tech social network	2, 25, 26
	Build a get to know you Seppo tour	1,3,4,5,8,24, 25
Innovation	Exercise: the sniffing dog	8, 10, 16, 26
	Exercise: decision roadmap	3, 4, 17
	Exercise: re- engineering concepts	1,2, 3
Design Thinking I	Exercise: knowing without knowing	5, 16, 24
	Exercise: Debate	3, 4, 17,
	Exercise: Google gaggle	5, 16, 25,26
	Exercise: Assumption Busting	5, 16, 25
Design Thinking II	Exercise: Soul searching	5, 16, 25
	Exercise: Crazy quilt	5, 15, 18, 24, 26
	Exercise: Refurbishing the house	2, 11, 21, 24

2.2. Local and international implementation

The piloting phase of the G4C:NGE curriculum employed a dual approach, combining local implementation at participating universities and international collaboration through transnational bootcamps. This enabled thorough testing within institutions and cross-cultural learning. Locally, the "Next Generation Entrepreneurship" course was integrated into 14 regular programs. Formats varied from in-person teaching to distance learning. Over 700 students from more than 20 nations took part in the pilot phases, with the bootcamps alone involving 100 students in cross-institutional activities. Additionally, 22 lecturers contributed to the course's design, delivery, and evaluation, enriching the teaching environment.

2.3. Development of an online platform

Within the scope of the project, a fully functional, integrated, and sustainable digital learning platform was developed, serving as the central ecosystem for all G4C:NGE activities. The conception and implementation were based on a pre-implementation report that defined the specific technical, functional, and quality requirements, incorporating input from partner organizations and target groups. The platform consists of two core components: the public G4C Gateway and the G4C Hub, which provides differentiated access areas for teachers and students, user management, access to case studies, tools and gamification scenarios, as well as all course materials of the NGE project.

Key outcomes of the platform development include the design and publication of two certified self-study courses: a gamified training course for teachers and an entrepreneurship course for students. Both courses utilize narrative elements, point systems, badges, and creative tasks to combine the development of digital competences with an introduction to gamified learning methodologies. In this way, the platform substantially supports the project's objectives regarding methodological innovation, provision of toolkits, and promotion of digital skills.

The usability of the platform was practically demonstrated and tested in workshops with students and teachers at the partner institutions. These events confirmed high usability and contributed to the establishment of a cross-border community of educators and learners. In total, 11 student workshops with 212 participants were conducted, significantly exceeding the original expectations. In the area of teacher workshops, 5–7 events were held in accordance with project goals. The number of registrations and course enrolments on the platform reached the targeted range of 300–500 users.

The platform was evaluated using defined quantitative and qualitative indicators. Quantitative indicators included the timely completion and partner approval of key documentation (Pre-Implementation Report and Post-Implementation Quality Report), the scheduled implementation and launch of platform components, as well as the number of designed and certified self-study courses. The achievement and surpassing of workshop and participant targets, as well as user statistics, demonstrate the broad acceptance and effectiveness of the platform.

Qualitative indicators encompassed compliance with the defined requirements, usability, and the didactic quality of materials and courses. The final evaluation document confirms that all technical and functional specifications were fully met or exceeded. User feedback from workshops and online surveys

highlighted the high acceptance and practical value of the platform; iterative improvements were continuously implemented based on this feedback. The quality assurance of course content and gamification elements were ensured by peer review conducted by subject-matter experts, confirming alignment with the overarching pedagogical principles of the project.

3. Evaluation and findings

Various metrics or benchmarks were used to assess the implementation of the pilot projects at each higher education institution, e.g., in relation to the achievement of the project objectives, student learning outcomes and the need for future optimisation of content and curricula. These may include student performance metrics, feedback mechanisms and post-pilot assessments (e.g. Bin Mubayrik, 2020). A community-based participatory evaluation approach ensures the assessment of learning outcomes in the pilot courses and bootcamp activities and improves the overall quality of the process, implementation and results. The following instruments are planned and have already been implemented for evaluation and quality assurance:

- Pre-Semester survey to assess teachers' and learners' prior knowledge of the curriculum topic and previous experience with game-based learning.
- Formative assessment, for obtaining continuous feedback during the piloting phase of the NGE course to assess the course structure, progress, and teaching methods so that, as needed, adjustments can be made and learning outcomes improved.
- Summative assessment to evaluate the effectiveness of the curriculum after completion of the course, measuring teacher and student satisfaction with the curriculum, assessing knowledge acquired, surveys regarding the use of materials provided, such as the presentation, descriptions and Moodle platform, and the use of gamified elements.

Effectiveness and usability of the modules were assessed using a wide range of quantitative and qualitative indicators. In total, 14 pilot iterations at four universities were carried out far surpassing initial targets. Pre- and post-semester surveys yielded 233 and 105 responses, respectively, complemented by 14 lecturer questionnaires and instructor focus groups.

3.1. Quantitative findings

- 49% of students reported that gamification significantly increased their motivation.
- 63% gained confidence in presenting ideas, especially via creative methods such as Pecha-Kucha.
- 72% reported improvement in collaboration skills, particularly within international teams.
- Over half felt more creative, producing innovative solutions and projects.
- Two-thirds said their expectations were largely or fully met, with overall satisfaction ratings very high.
- Quantitative results also showed substantial competence gains in motivation, communication, teamwork, and creativity each increasing by approximately one scale point or more on the five-point metric.

Qualitative Findings: Students highlighted the value of engagement, teamwork, and international exchange. The most valued competences were teamwork, confidence, and creativity. Challenges included workload, fast pacing, and at times unclear assessment formats. Methods such as storytelling, peer review via Miro, and case-based gamification design were singled out as highly effective.

Practitioner Reflections: Teachers reported a sense of *professional renewal* through a shift from content delivery to facilitation. Participation in CPD workshops and peer exchange was regarded as an integral part of professional development. While workload was acknowledged as a challenge, institutional support and IT enablement offered meaningful compensation. Project partners especially stressed the need for curriculum embedding, development of playbooks, and adoption of micro-credentials.

In summary, the results demonstrate that the modules exceeded expectations, making a sustainable contribution to quality, impact, and adaptability in university teaching.

4. Conclusions

The implementation of the G4C:NGE project confirmed that gamification positively influences student engagement, motivation, and cognitive development. To enhance learning, the project should expand its gamified elements, particularly through digital and competitive formats. Playful learning fosters critical future skills, but effective implementation requires integrating game elements meaningfully with academic content. Encouraging students to design their own game-based experiences promotes deeper understanding and develops entrepreneurial mindsets, provided educators offer careful guidance. Student and lecturer feedback suggests refining instructions, increasing practice activities, reducing complexity,

and aligning assessments. Intercultural exchange and collaboration remain key strengths. By addressing these points, G4C:NGE can further improve its curriculum and strengthen playful learning in entrepreneurship education.

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EXPLORING TEACHER PERCEPTIONS OF INTEGRATING STEAM AND HOME ECONOMICS THROUGH THE STEAMKITCHEN HANDBOOK

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Abstract

The integration of Science, Technology, Engineering, Arts and Mathematics (STEAM) across school subjects supports meaningful learning and 21st-century competencies. Home Economics offers a natural context for STEAM because it links scientific, technological, mathematical and creative knowledge to everyday practices. The STEAMKitchen project (Erasmus+ KA220-HED) produced a teacher handbook of practical, food-based learning activities that connect STEAM concepts with Home Economics. This study used a descriptive, mixed-methods design to examine in-service teachers' perceptions following a one-day STEAMKitchen professional development seminar introducing the handbook. Post-event feedback from 28 teachers was collected via an anonymous online survey comprising Likert-type items and open questions addressing clarity, curricular integration, pedagogical relevance, 21st-century skills, motivation and inclusivity. Quantitative responses were summarised with descriptive statistics (means, SDs); qualitative responses were analysed thematically. Results show uniformly positive reception: teachers rated the handbook highly for practical applicability and interdisciplinary integration (e.g., STEAM integration M = 4.71), and described experienced food-based tasks (chocolate, pH and temperature experiments) as effective bridges between Home Economics and STEAM. Teachers also reported perceived gains in confidence and ideas for classroom adaptation. The seminar format, combining short theoretical framing with hands-on practice, supported teachers' readiness to adapt interdisciplinary tasks.

Keywords: *Home economics, STEAM education, interdisciplinary teaching.*

1. Introduction

STEAM education (Science, Technology, Engineering, Arts and Mathematics) has become a globally visible and influential educational approach over the past decade, promoted as a response to complex societal challenges that require interdisciplinary thinking, creativity, and problem-solving skills (Perignat & Katz-Buonincontro, 2019). Rather than focusing on isolated disciplinary knowledge, STEAM emphasizes the meaningful integration of scientific, technological, artistic, and ethical perspectives in authentic, real-life contexts, supporting the development of key 21st-century competencies such as critical and creative thinking, collaboration, and sustainability-oriented problem solving. In this sense, STEAM has been described not only as an interdisciplinary framework but also as a broader educational shift toward a more humanistic and socially responsive conception of schooling (Perales & Aróstegui, 2024). Recent frameworks further highlight STEAM's potential to address real-world and so-called "wicked problems" through practice-oriented approaches that combine thinking, making, and doing in meaningful contexts (Chappell, Hetherington, Juillard, Aguirre, & Duca, 2025). Home economics education offers a particularly suitable context for implementing STEAM principles, as it inherently connects theory and practice through everyday activities such as food preparation, consumption, material use, and household decision-making. By linking scientific and technological knowledge with daily life practices, home economics supports students' ability to apply knowledge meaningfully and to develop responsible and sustainable ways of living. Previous research has shown that home economics contributes to students' holistic development and the acquisition of 21st-century skills, particularly in relation to sustainability and everyday life competence (Taar & Palojoki, 2022).

In recent years, the integration of home economics within STEAM education has gained increasing international attention. The International Federation for Home Economics (IFHE) emphasizes that home economics provides a unique bridge between science- and technology-based knowledge and learners' everyday lives, enabling students to actively shape sustainable lifestyles (IFHE, 2025). This view is

supported by recent research synthesizing international studies, which demonstrates strong conceptual and pedagogical connections between home economics and STEAM, particularly in fostering problem-solving skills, creativity, and real-world application of knowledge (Heinmäe, Callaghan, & Taar, 2025). Despite this growing recognition, systematic integration of STEAM and home economics remains limited in educational practice, especially in terms of practical teaching materials and structured professional development opportunities for teachers.

To address this gap, the international STEAMKitchen project was initiated to demonstrate, through concrete examples, how STEAM education and home economics can be meaningfully combined in everyday teaching practice. STEAMKitchen is a two-year ERASMUS+ KA220-HED project (2024–2026) involving partner institutions from Estonia, Finland, Austria, and Norway, bringing together complementary expertise in home economics and STEAM teacher education. The project aims to support teachers, teacher educators, and other educational stakeholders by providing research-informed yet practice-oriented solutions developed through international collaboration (Paas & Taar, 2025).

Within the project, Work Package 2 focused on strengthening interaction between practice, research, and policy through the development of guidelines illustrating how STEAM principles can be integrated with home economics (Paas et al., 2025a). Work Package 3 built on this foundation by developing a teacher handbook containing 20 practice-oriented learning task ideas that integrate STEAM and home economics across different age groups and educational contexts (Paas et al., 2025b).

The present article focuses on the STEAMKitchen teacher handbook developed within Work Package 3 and on its introduction during a one-day professional seminar for in-service teachers. The study is grounded in the understanding that teachers play a key role in creating meaningful learning environments and implementing interdisciplinary approaches in school practice. Research on teacher professional development identifies active learning, such as hands-on engagement, reflection, and collaborative meaning-making, as a core feature of effective professional development that supports the transfer of new ideas into classroom practice (Desimone & Garet, 2015). This focus is further supported by international evidence from the OECD Teaching and Learning International Survey (TALIS), which highlights teachers as intrinsically motivated professionals who value practice-oriented and collaborative professional learning opportunities (OECD, 2019).

The aim of this study was to evaluate the effectiveness of the STEAMKitchen professional development seminar in supporting teachers' understanding, confidence, and readiness to implement interdisciplinary home economics–STEAM activities. Specifically, the study explored teachers' perceptions of the handbook's clarity, pedagogical relevance, practical applicability, and its potential to support 21st-century skills and inclusive learning.

2. Methods

This study employed a descriptive research (Creswell, 2009) to examine in-service teachers' perceptions of a one-day STEAMKitchen professional development seminar and the accompanying Teacher Handbook following their introduction to practice. The aim was to document teachers' experiences, perceived relevance, and usability of the materials as part of their dissemination to educational practice. The seminar was designed as a hands-on professional development event introducing teachers to selected activities from the STEAMKitchen handbook through a short project introduction and a rotating workshop format. Participants engaged in three hands-on activity stations representing different integrations of STEAM and home economics, as well as one facilitated reflection workshop focusing on sustainability-related dimensions. The aim of the seminar was to enable teachers to experience the activities as learners and to reflect on their pedagogical value and applicability in school practice.

The seminar took place at Tallinn University, Estonia, and was organised by the local project team. Although similar seminars were conducted by project partners in other countries, the present article focuses exclusively on the Estonian case to allow for a contextualised description of the seminar format and a coherent analysis of teacher feedback.

Data were collected using an online questionnaire administered via Google Forms. The questionnaire included both Likert-type items and open-ended questions addressing teachers' perceptions of the seminar structure, pedagogical relevance, interdisciplinarity, sustainability, motivation, collaboration, and inclusivity. The Likert-type items used a five-point response scale ranging from 1 ("not at all") to 5 ("absolutely"). Participation in the questionnaire was voluntary, and ethical principles as well as General Data Protection Regulation (GDPR) requirements guided the data collection process. All participants provided informed consent for the anonymised use of their responses in scientific publications.

The seminar was open, free of charge, and limited to 40 registered participants. On the seminar day, 33 teachers attended, of whom 29 completed the questionnaire. One respondent did not consent to the

scientific use of their data and was therefore excluded from the analysis. The final data set consisted of 28 valid responses.

Quantitative data from the Likert-type items were analysed using descriptive statistics, including frequencies, mean values, and standard deviations, to summarise overall trends in teachers' perceptions of the seminar and the STEAMKitchen Handbook. Although Likert-type items are ordinal in nature, the use of mean values for descriptive purposes is widely accepted in educational research when the aim is to describe general tendencies rather than to make inferential claims (Joshi, Kale, Chandel, & Pal, 2015). Qualitative data from open-ended questions were analysed using thematic content analysis (Braun & Clarke, 2006). Responses were read iteratively, recurring themes were identified and coded, and illustrative excerpts were selected and translated into English for reporting. Given the formative and context-specific nature of the study and the relatively small sample size, the analysis emphasised descriptive interpretation and actionable feedback rather than statistical generalisation.

3. Results

The participating teachers represented a highly experienced professional group. Of the respondents, 22 teachers reported more than nine years of teaching experience, five teachers had between three and eight years of experience, and one teacher reported less than three years of experience. Teachers came from different regions across Estonia, reflecting a geographically diverse sample of in-service teachers. The participating teachers represented a range of subject backgrounds, with the majority teaching home economics and handicraft, either as a main subject or in combination with related fields. Several teachers also taught technology education and art, reflecting strong links between practical, creative, and design-oriented subjects. In addition, a smaller number of participants represented STEAM-related subjects, including chemistry, biology, natural sciences and mathematics. This diversity highlights the interdisciplinary relevance of the STEAMKitchen seminar for teachers across both home economics and STEAM subject areas.

Overall, teachers' responses to the Likert-scale items indicate very positive perceptions of the STEAMKitchen activities and supporting materials. On a five-point scale, teachers evaluated the structure of the activities as clear and easy to follow ($M = 4.75$, $SD = 0.44$). The handouts and accompanying information were also rated highly in terms of supporting implementation in practice ($M = 4.68$, $SD = 0.55$). When asked to position the activities on a practical–theoretical continuum, teachers' responses indicated a clear emphasis on practical orientation ($M = 2.57$, $SD = 1.26$), where lower values represented a more practice-oriented approach. This suggests that teachers perceived the activities primarily as hands-on and applicable to classroom practice rather than predominantly theoretical.

Teachers assessed the integration of subject content very positively. The integration of home economics topics, such as nutrition, food, and household-related themes, was rated as valuable ($M = 4.57$, $SD = 0.69$). Similarly, teachers reported strong integration of multiple STEAM subjects within the activities ($M = 4.71$, $SD = 0.46$). Sustainability was consistently rated as a clearly embedded and meaningful component of the activities. Teachers evaluated both the communication of the importance of sustainability ($M = 4.50$, $SD = 0.51$) and the extent to which sustainability was present in the activities ($M = 4.50$, $SD = 0.58$) at a high level.

Teachers also reported that the activities properly represented their subject content, whether related to home economics (e.g., health and everyday life) or STEAM-related scientific and socio-scientific topics ($M = 4.57$, $SD = 0.57$). In addition, teachers indicated that the activities supported going beyond the existing curriculum by addressing additional topics relevant to everyday life ($M = 4.86$, $SD = 0.36$), which received the highest mean score among all items.

The development of 21st-century skills—specifically creativity, collaboration, cooperation, and critical thinking—was rated highly by teachers ($M = 4.71$, $SD = 0.53$). Teachers also reported increased motivation and ideas for collaboration with colleagues following the seminar ($M = 4.64$, $SD = 0.49$), and evaluated the goals of the STEAMKitchen project as motivating ($M = 4.61$, $SD = 0.63$).

Teachers perceived the activities as motivating for students ($M = 4.54$, $SD = 0.74$) and inclusive for a wide range of learners ($M = 4.46$, $SD = 0.69$). Inclusivity was also rated highly from the teachers' perspective, with respondents indicating that the activities were suitable for teachers of different levels, subjects, ages, genders, and cultural backgrounds ($M = 4.68$, $SD = 0.48$).

Teachers' open-ended responses largely supported the high quantitative ratings across all evaluated dimensions. In particular, teachers provided concrete examples of how interdisciplinary integration was realized through food-based activities involving chocolate, pH measurement, and temperature, which were frequently mentioned as effective bridges between home economics and STEAM subjects. One teacher noted, "From one simple everyday product, it is possible to design a highly versatile and integrated lesson."

Similarly, sustainability, highly rated in the quantitative results, was described as being embedded naturally across activities through discussions of energy use, food choices, waste, and everyday household practices. Teachers also highlighted hands-on experimentation and real-life relevance as key motivational factors for students, reinforcing the strong ratings related to practicality and student engagement. Finally, inclusivity was reflected in teachers' descriptions of multiple entry points, adaptability, and the possibility to address diverse learners and perspectives within the same activities.

4. Discussion

The findings of this study indicate a highly positive reception of the STEAMKitchen teacher seminar and the accompanying handbook, highlighting the value of experiential and practice-oriented professional development for supporting interdisciplinary teaching. Teachers' open-ended responses complemented the quantitative results by illustrating how food-based activities (particularly those they experienced), related to chocolate exploration, pH measurement using natural indicators, and temperature experiments, functioned as effective focal points for integrating home economics with chemistry, physics, and biology. These activities provided concrete, sensory-rich contexts that made interdisciplinary connections visible and accessible. The findings also reinforce research identifying home economics as a natural and pedagogically meaningful context for STEAM integration. Teachers' experiences with food-based activities illustrate how scientific, technological, mathematical, and creative elements converge in everyday home economics practices, supporting recent review findings that highlight strong conceptual and pedagogical overlap between home economics and STEAM (Heinmäe et al., 2025).

Sustainability emerged as a meaningful and integrated dimension of the activities rather than an isolated topic. Teachers described how issues such as food production chains, energy use, everyday consumption choices, and material reuse were naturally embedded in practical tasks and discussions. This embedded approach aligns with teachers' high quantitative ratings for sustainability and supports the idea that sustainability education is most effective when linked to everyday practices and real-life decision-making.

Beyond specific content knowledge gains, many teachers reported broader professional learning outcomes, including a shift toward more holistic and interdisciplinary thinking. Several participants described increased awareness of STEAM connections across subjects and greater confidence in designing integrated lessons. Practical, hands-on engagement was consistently identified as a key motivational factor for students, alongside real-life relevance, collaboration, and the use of familiar materials. Teachers also noted that the activities offered flexibility and multiple entry points, supporting inclusivity through differentiated approaches, cultural connections, and varied learner needs.

Importantly, teachers emphasised adaptation rather than direct replication of the activities. Experiencing the tasks as learners during the seminar enabled them to envision how similar principles could be transferred and modified for their own classroom contexts. This finding suggests that experiential professional development supports sustainable pedagogical change by encouraging teachers to internalise underlying ideas and apply them flexibly rather than follow fixed lesson scripts.

These findings reinforce the central role of teachers as key agents in implementing interdisciplinary and innovative educational approaches such as the integration of home economics and STEAM. Teachers' feedback indicates that hands-on, practice-oriented professional development can strengthen their understanding of interdisciplinary concepts and increase confidence in applying them in everyday teaching practice. This aligns with international evidence from TALIS (OECD, 2019), which highlights teachers as intrinsically motivated professionals who value professional development that is relevant, collaborative, and closely connected to classroom practice.

The seminar format used in the STEAMKitchen project reflects several features identified in the literature as characteristic of effective teacher professional development. Teachers' opportunities for active engagement, reflection, and collective participation correspond with research emphasising active learning as a critical condition for meaningful professional learning (Desimone & Garet, 2015). By situating STEAM principles within familiar and meaningful everyday contexts, such as those provided by home economics, the STEAMKitchen Teacher Handbook appears to lower barriers to interdisciplinary teaching and support teachers in envisioning implementation across subject boundaries and age levels. This finding is consistent with earlier research indicating that professional development is most effective when closely aligned with teachers' curricular responsibilities and classroom realities.

5. Conclusion

The results suggest that the STEAMKitchen professional development seminar effectively supports teachers in adopting interdisciplinary Home Economics and STEAM practices. Providing both conceptual grounding and experiential learning opportunities enhanced teachers' confidence and perceived readiness to implement the handbook in their own teaching.

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COMPLEX ASSESSMENT AND MULTIDISCIPLINARY INTERVENTION IN CHILDREN AFTER PEDIATRIC STROKE USING MYRO: SYSTEMATIC CASE STUDY

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Abstract

Background: Pediatric stroke is a rare but serious neurological condition associated with persistent motor, cognitive, and functional deficits in up to 40–70% of affected children. Technology-assisted multidisciplinary rehabilitation may improve functional outcomes; however, evidence remains limited. *Objective:* To evaluate functional changes in upper-limb motor function, manual dexterity, grip strength, graphomotor performance, and self-care abilities following a structured MYRO®-based intervention in two children with hemiparesis after pediatric stroke. *Methods:* A systematic longitudinal case-study design was applied. Two children (7 and 11 years) with confirmed pediatric ischemic stroke completed a 10-session individualized MYRO®-assisted intervention delivered over 10 weeks within a multidisciplinary rehabilitation framework. Standardized pre- and post-intervention assessments included Box and Blocks Test (BBT), Nine-Hole Peg Test (NHPT), JAMAR dynamometry, graphomotor assessment (DiaGraMo/MaTeRs), self-care evaluation (Čadová scale), and MYRO® digital metrics. Clinically meaningful change was evaluated using minimal detectable change (MDC95) and Reliable Change Index (RCI) where applicable. *Results:* Both participants demonstrated clinically meaningful improvements in manual dexterity, grip strength, graphomotor coordination, and self-care independence. Improvements exceeded MDC thresholds in key motor outcomes, and affected-limb functional use increased in both cases. *Conclusion:* Integration of interactive MYRO®-based therapy within multidisciplinary pediatric neurorehabilitation may contribute to clinically relevant improvements in motor and functional outcomes. Systematic longitudinal case monitoring represents a methodologically appropriate approach in low-incidence pediatric conditions.

Keywords: *Pediatric stroke, case study, MYRO, graphomotor skills, self-care, motor recovery.*

1. Introduction

Pediatric stroke represents a rare but clinically significant neurological condition associated with long-term motor, cognitive, and participation limitations. Reported annual incidence rates are approximately 1–2 per 100,000 children for ischemic stroke and 1–1.7 per 100,000 for hemorrhagic stroke, while perinatal stroke occurs more frequently (Lehman et al., 2018; Paulasová Schwabová & Paulas, 2022; Gao et al., 2023). Despite the relatively low prevalence, 40–70% of affected children develop persistent neurological deficits, particularly unilateral motor impairment affecting activities of daily living (ADL) and school participation (Rivella et al., 2022; Champigny et al., 2024; Singh et al., 2024).

The low incidence of pediatric stroke substantially limits the feasibility of large randomized trials and frequently results in small heterogeneous research samples. Consequently, systematic longitudinal case-study designs represent a methodologically appropriate approach for investigating recovery trajectories and evaluating intervention effects at the intra-individual level (Cooper et al., 2019; Mota et al., 2022). Repeated standardized measurements allow detection of clinically meaningful change using indicators such as minimal detectable change (MDC) and Reliable Change Index (RCI), providing clinically interpretable evidence in exploratory intervention research involving rare pediatric conditions.

Current rehabilitation recommendations emphasize multidisciplinary approaches integrating task-oriented practice and technology-assisted therapy targeting both motor capacity and functional performance (Hart et al., 2022; Mrakotsky et al., 2022). Interactive rehabilitation systems such as MYRO® enable task-specific practice with real-time feedback and objective performance monitoring; however, systematic evidence regarding their use in pediatric stroke rehabilitation remains limited.

Therefore, this study aimed to examine functional changes following a structured MYRO®-based multidisciplinary intervention.

2. Methods

2.1. Study design

This study employed a systematic longitudinal case-study design with identical pre- and post-intervention assessments. Given the rarity of pediatric stroke and the heterogeneity of recovery trajectories, systematic case-study approaches represent an appropriate methodology for monitoring individualized functional change over time in pediatric neurorehabilitation research (Hollist et al., 2021; Malone et al., 2022). Repeated standardized measurements further enabled interpretation of clinically meaningful functional change using indicators such as minimal detectable change (MDC95) and Reliable Change Index (RCI) (Jacobson & Truax, 1991).

2.2. Participants

Two children (female, 7 years; male, 11 years) diagnosed with pediatric ischemic stroke and unilateral hemiparesis were recruited using purposive sampling.

Participants met the following inclusion criteria: confirmed pediatric stroke diagnosis, age between 6 and 15 years, and ability to participate in structured therapeutic activities requiring interaction with rehabilitation tasks.

Exclusion criteria included other neurological diagnoses, neuromuscular disorders, epilepsy, moderate-to-severe intellectual disability limiting task interaction, and severe receptive aphasia interfering with comprehension of instructions.

2.3. Ethical considerations

Written informed consent for participation and publication of anonymized data was obtained from the legal guardians of both participants. All procedures were conducted in accordance with institutional ethical standards and the principles of the Declaration of Helsinki (Hollist et al., 2021).

2.4. Intervention

Participants completed ten individualized MYRO®-based therapy sessions lasting 30 minutes each over approximately ten weeks. Therapy was delivered by an occupational or physiotherapist in collaboration with a special educator within a multidisciplinary rehabilitation framework. Multidisciplinary and task-oriented rehabilitation approaches supported by interactive technologies are increasingly recommended as part of contemporary pediatric stroke rehabilitation strategies (Hart et al., 2022; Mrakotsky et al., 2022; Malone et al., 2022).

The intervention targeted upper-limb coordination and strength, visuomotor integration, bilateral motor use, and cognitive-motor functions including attention and motor planning.

2.5. Outcome measures

Motor and functional outcomes were assessed using standardized instruments:

- Box and Blocks Test (manual dexterity)
- Nine-Hole Peg Test (fine motor coordination)
- JAMAR dynamometer (grip strength)
- DiaGraMo / MaTeRs (graphomotor performance)
- Self-Care Assessment Scale[1] (Čadová et al.)
- MYRO® digital performance indicators

Clinically meaningful change was evaluated using MDC95 and Reliable Change Index (RCI) where available.

3. Results

Both participants demonstrated improvement across motor, functional, and participation-level indicators. Gains were consistent with clinically meaningful intra-individual change and reflected increased functional use of the affected limb.

[1]Czech assessment scale developed and focued on school environment, can be administred by special needs teacher

Table 1. Pre-post outcomes by case.

Outcome	Case	Pre-test	Post-test	MDC95	RCI	Interpretation
Box and Blocks Test (affected limb)	Case 1	0 blocks	measurable functional performance	1.9–1.7	≈ +6	Restoration of functional use
	Case 2	13.3 blocks	improved beyond MDC	1.9–1.7	≈ +13.1	Clinically meaningful dexterity gain
Nine-Hole Peg Test	Case 1	25.32 s	23.1 s	2.16	−2.02	Reliable fine-motor improvement
	Case 2	not executable	executable post-test	—	—	Recovery of task ability
Grip strength (JAMAR)	Case 1	3.1 kg / 0 kg	7.3 kg / 0.8 kg	n/a	n/a	Clinically meaningful strength gain
	Case 2	17.4 kg / 3.8 kg	increased values	n/a	n/a	Functional improvement
Graphomotor performance	Case 1	unstable performance	improved coordination and bilateral use	n/a	n/a	Improved graphomotor control
	Case 2	reduced stability	improved stability and spatial control	n/a	n/a	Functional graphomotor gain
Self-care independence	Case 1	dependence level 3–4	level 1–2	n/a	n/a	Increased independence
	Case 2	assistance required	reduced assistance	n/a	n/a	Improved ADL performance

4. Discussion

The present systematic case study demonstrated clinically meaningful improvements in motor performance, functional independence, and graphomotor abilities following a short MYRO®-based multidisciplinary intervention.

Importantly, improvements were not limited to motor capacity but extended to daily functional performance, particularly self-care activities, suggesting transfer of therapy effects to real-life contexts. This aligns with contemporary neurorehabilitation models emphasizing task-oriented functional training.

Given the rarity of pediatric stroke and resulting methodological challenges in conducting large trials, longitudinal systematic case-study designs provide valuable clinically interpretable evidence and enable detailed monitoring of individualized recovery trajectories.

Limitations include small sample size and absence of long-term follow-up; nevertheless, systematic repeated measurement and multimodal assessment strengthen the internal validity of findings.

5. Conclusion

A short MYRO®-based multidisciplinary intervention produced clinically meaningful improvements in motor function, graphomotor performance, and independence in daily activities in two pediatric stroke cases. Technology-supported functional training combined with standardized monitoring may represent a promising approach for individualized pediatric neurorehabilitation.

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USING KNOWLEDGE GRAPHS TO STRUCTURE AND SUMMARIZE INSTRUCTION IN STEM CLASSROOMS

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Abstract

In the context of 21st-century STEM education, knowledge graphs (KGs) have emerged as powerful pedagogical tools for structuring, visualizing, and summarizing complex instructional content. These structured visual representations map relationships between concepts, enabling learners to navigate abstract domains such as mathematics and computer science with greater clarity and depth. Contemporary pedagogical models position knowledge graphs not only as cognitive scaffolds but also as epistemological organizers that reflect the internal logic of STEM disciplines, thereby supporting meaningful learning and disciplinary fluency. A pilot study conducted at Kaye College of Education and Achva Academic College in Israel examined the integration of knowledge graphs into STEM instruction. At Kaye, the focus was on pre-service secondary school teacher education (N=5), where graphs were used to support pedagogical analysis and conceptual development in a Numerical Analysis course. At Achva, knowledge graphs were embedded in a Data Structures course, helping first-year undergraduate computer science students (N=9) visualize algorithmic relationships and consolidate their learning during summary lectures. Across both institutions, the instructional model emphasized four instructional principles derived from research on meaningful learning and visual knowledge representations: 1) Conceptual Organization – Structuring content around central ideas and their interrelations. 2) Cognitive Visibility – Making abstract relationships tangible through visual mapping. 3) Comparative Reasoning – Highlighting similarities and differences between concepts. 4) Reflective Integration – Using graphs to summarize and reinterpret knowledge. Preliminary findings from both colleges indicate positive effects on students' engagement, understanding, and perceived ability to articulate conceptual connections. Students reported that knowledge graphs clarified abstract ideas and supported deeper reflection. From the instructor-researcher perspective, the graphs appeared to support more focused classroom dialogue by providing a shared reference for comparison. Knowledge graphs, therefore, offer a promising framework for organizing and summarizing instruction in STEM classrooms.

Keywords: *Knowledge graphs, STEM education, epistemic representations, comparative reasoning, meaningful learning.*

1. Introduction

In STEM education, students and instructors frequently encounter knowledge domains whose internal organization is not immediately evident. Courses in mathematics and computer science are typically presented as sequences of topics. In contrast, the relational structures that confer coherence upon the discipline, including dependencies, abstractions, implementation hierarchies, and alternative solution paths, often remain implicit. Consequently, learners may acquire isolated techniques without developing an integrated understanding of how ideas interrelate, thereby constraining transfer and disciplinary reasoning (Ausubel, 1968; Marton, 2015). One way to address this challenge is to make the structure of the subject explicit through visual representations such as concept maps. Research indicates that making conceptual relationships visible improves integration and achievement in STEM (Wang et al., 2025).

Knowledge graphs (KGs) extend this idea by representing entities and explicitly typed relations grounded in a semantic schema or ontology (Gruber, 1993; Hogan et al., 2021; Paulheim, 2017). Unlike informal diagrams, they encode types of concepts and relations in ways that support both human interpretation and computational processing, making hierarchies, dependencies, alternatives, and constraints explicit and open to inspection (Berners-Lee, Hendler, & Lassila, 2001). In educational contexts, such graph-structured representations can expose and reorganize the conceptual architecture of a domain, enabling learners to engage more directly with relationships among ideas. Recent reviews indicate that knowledge graph approaches can support curriculum design, concept instruction, and personalized learning in higher education (Abu-Salih & Alotaibi, 2024; Qu, Li, Wong, Wu, & Liu, 2024). In learning technologies, KGs are also used to model domain knowledge and learner state for adaptive feedback and

prerequisite tracing (Dang et al., 2021; Wang, Burke, Poulos, Iqbal, & Lee, 2024), consistent with research emphasizing that well-structured knowledge representations support transfer and problem solving (Bransford, Brown, & Cocking, 2000).

Although KGs are formally graphs in the mathematical sense, the present study does not treat them primarily as computational structures. Rather, they are employed as structured pedagogical representations that make conceptual relationships explicit within classroom practice. In this respect, they resemble concept maps in their instructional function while maintaining explicitly typed relations characteristic of knowledge graph representations. This relational explicitness enables KGs to function not only as visual summaries but also as shared classroom artefacts that support comparison, explanation, and disciplinary reasoning. However, much of the existing literature positions KGs primarily as computational infrastructures or instructional planning tools, and far less attention has been given to their role as participatory classroom artefacts that shape discourse, comparison, and disciplinary reasoning during instruction.

Consequently, the present study investigates how instructor-constructed KGs function in regular STEM classrooms as epistemic representations that make disciplinary structure explicit and accessible to inquiry. We report a mixed-methods pilot study conducted at two Israeli institutions, Kaye College of Education and Achva Academic College, in which KGs were integrated into a Numerical Analysis course for pre-service mathematics teachers and a Data Structures course for computer science undergraduates. The instructional design was guided by four core principles informed by research on meaningful learning, conceptual organization, and visual knowledge representations: conceptual organization (structuring content around central ideas and their interrelations); cognitive visibility (making abstract relationships tangible through visual mapping); comparative reasoning (highlighting similarities and differences between concepts); and reflective integration (using graphs to summarize and reinterpret knowledge) (Ausubel, 1968; Novak & Gowin, 1984; Ainsworth, 2006; Linn, 2006).

The study asked: (1) How do students perceive instructor-constructed KGs as tools for organizing disciplinary knowledge? (2) How do knowledge graph representations support students in articulating conceptual relationships and comparing alternative solutions?

2. Research design and methodology

2.1. Methodology and context

This study employed a mixed-methods convergent parallel design (Creswell & Plano Clark, 2017). Qualitative and quantitative data were collected concurrently, analysed separately, and integrated during interpretation. The quantitative strand consisted of a researcher-developed questionnaire comprising 27 Likert-type items rated on a five-point scale (1 = very little extent, 5 = very great extent). The qualitative strand consisted of open-ended questionnaire responses analysed using thematic analysis, focusing on how participants described the role of KGs in organizing concepts and supporting comparison (Shkedi, 2011).

The study involved two sources of evidence: (a) the instructor-constructed knowledge graphs used as pedagogical artefacts; and (b) a questionnaire administered during a summary lecture in each course, including both structured Likert-type items and open-ended questions focusing on students' experiences with the knowledge graph activities.

The first context was a Numerical Analysis course for third-year pre-service secondary school mathematics teachers (N=5) at Kaye College of Education, a teacher-education institution in Israel. The course introduces foundational numerical methods (e.g., root-finding, numerical integration, iterative methods) and the associated concepts of complexity, convergence, error, and stability. It enrolls advanced undergraduates preparing for secondary school teaching. The second context was a Data Structures course for first-year computer science undergraduates (N=9) at Achva Academic College, which covered asymptotic analysis, basic algorithms (searching and sorting), linear data structures (linked lists, stacks, queues), and non-linear data structures (graphs, trees, heaps). In both settings, the instructor was a member of the research team and designed knowledge graph-based activities as part of regular course instruction.

The study was conducted in accordance with international ethical standards. The questionnaire was anonymous, ethical approval was obtained from the Institutional Ethics Committees of Achva Academic College and Kaye College of Education, and all participants provided informed consent.

2.2. Research design

In both courses, instructor-constructed knowledge graphs (KGs) were integrated into planned lectures (a summary lecture in Numerical Analysis; recurring topic lectures in Data Structures) to make the relationships among key course concepts explicit. The graphs were constructed based on the conceptual structure of the course syllabus and the instructional materials used in teaching, including lecture notes and the central topics addressed in the lectures. Content validity was established through expert review by two computer science and mathematics education experts, and minor revisions were implemented to improve clarity and precision. Concepts were selected to represent core entities within each unit (e.g., numerical methods, data structures, and abstract data types), while labeled relations represented meaningful

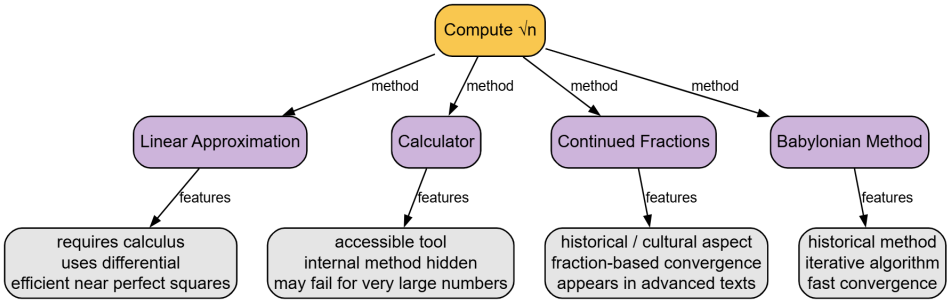
disciplinary connections such as *implements*, *depends on*, *generalizes*, and *is-a* (Zhitomirsky-Geffet & Avidan, 2022).

The design of the graphs was guided by four instructional principles underlying the study. Conceptual organization guided the selection of central concepts and their hierarchical relationships. Cognitive visibility shaped the visual representation of dependencies and conceptual groupings. Comparative reasoning was supported by including relations that allowed different methods, structures, or approaches to be examined within the same representation. Reflective integration was addressed by connecting graphs across units to support a broader conceptual view of the course.

In the Numerical Analysis course, a global KG was presented during a summary lecture to represent conceptual relationships among major course topics, including convergence, accuracy, stability, and computational cost. The graph served as a visual framework for discussing how different numerical methods relate to one another and for comparing alternative approaches to solving numerical problems. During the lecture, students were invited to interpret the graph, identify conceptual dependencies between methods, and discuss similarities and differences among numerical methods.

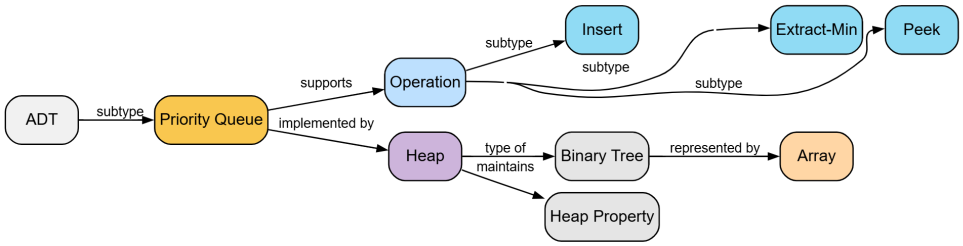
The knowledge graphs were created using *Graphviz*, an open-source graph visualization software, with structures defined using the DOT graph description language.

Figure 1. Part of the global KG from the Numerical Analysis summary lecture, showing a comparison between four methods of computing the square root (irrational number) of a natural number.



In the Data Structures course, instructor-constructed KGs were integrated throughout, with each graph corresponding to a major topic in the syllabus. These graphs represented relationships between abstract data types, concrete data structures, and associated operations. At the beginning of each thematic unit, a local KG was introduced to provide an overview of the topic's conceptual organization.

Figure 2. Local unit KG from Data Structures lecture, showing an abstract data type - priority queue.



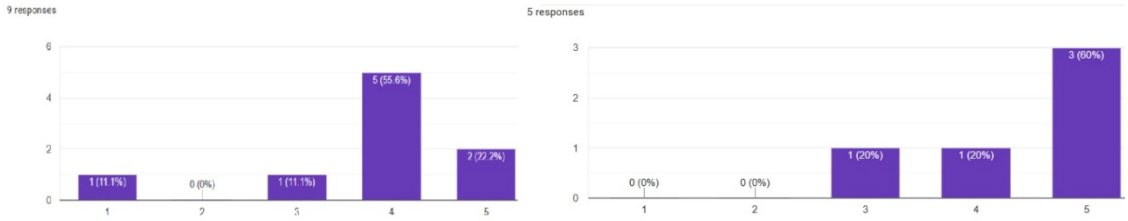
As instruction progressed, new concepts were incorporated into the graphs, and the relationships among them were discussed explicitly in class. At the end of each unit, the local graphs were connected to form an evolving course-level representation. This cumulative graph presented during the summary lecture allowed students to situate newly introduced concepts within a broader conceptual framework and to support discussion of implementation choices and complexity trade-offs across different data structures.

3. Findings and discussion

Quantitative analysis was based on Likert-type items assessing perceived clarity, structural organization of course content, support for comparison, and the overall usefulness of the graphs for understanding the course material. Due to the small sample size, quantitative results are presented using descriptive statistics and interpreted alongside the qualitative findings. Figures 3–4 provide illustrative distributions: most participants reported limited prior familiarity with KGs, and students in both courses rated the visual presentation of a KG as more beneficial than presenting concepts in written text.

Figure 3. Responses for the following question, both courses. Extent of prior familiarity with a knowledge graph before the course.

Figure 4. Responses for the following question, both courses. To what extent is a visual presentation of a knowledge graph in lectures and in the summary session more beneficial than presenting concepts in written text?



Qualitative analysis of open-ended questionnaire responses used thematic analysis to identify recurring perceptions of how KGs supported understanding, comparison, and integration (Shkedi, 2011).

Across both the Numerical Analysis and Data Structures courses, students reported that the KGs supported their understanding of complex relationships among course concepts and helped them integrate material more holistically. In the Numerical Analysis course, participants described the graphs as tools for "seeing the big picture". In response to the question: *"What, in your opinion, is the main added value of using a KG in a Numerical Analysis course?"* one participant wrote:

"*The ability to organize knowledge in a hierarchical and interconnected way, making it easier to understand the dependencies between topics.*"

The visual structure also helped students identify which ideas served as prerequisites and which represented more advanced or derived concepts, thereby supporting both study planning and exam revision. From the instructor-researcher perspective, the graphs served as shared reference points during whole-class discussions, particularly when comparing numerical methods or examining error behavior and convergence conditions.

Similar patterns emerged in the Data Structures course. Students indicated that progressively integrating topic-specific graphs into a global course-level representation helped them perceive the syllabus as a connected conceptual landscape rather than a sequence of discrete chapters. The global graph was used to position newly introduced structures, such as heaps, relative to earlier material on lists, trees, and graphs, and to reason about alternative implementation strategies for design problems. Some students reported tracing paths through the graph to compare solution strategies, such as array-based versus linked-list-based structures. In response to the question: *"How did integrating the KG improve your ability to explain complex course concepts to others?"* one participant explained:

"Integrating a knowledge graph allows me to map the relationships between key concepts visually. In a course like Data Structures and Algorithms, which includes abstract ideas (such as lists, trees, graphs, sorting, and complexity), presenting the connections between them as a knowledge graph can illustrate what depends on what, what builds on what, and how the ideas relate to one another. This enables a more intuitive explanation, not just a technical one."

Finally, a joint analysis integrating quantitative questionnaire results and qualitative responses was conducted to identify convergences across the data sources and strengthen the interpretation of the findings. Across the two courses, several cross-cutting themes aligned with the study's four design principles. First, the graphs supported conceptual organization by making prerequisites, thematic clusters, and relationships among topics explicit. Second, they enhanced cognitive visibility, helping students clarify misunderstandings and structure their revision. Third, they supported comparative reasoning by enabling students to juxtapose alternative methods, structures, or strategies within a shared representation. Fourth, they supported reflective integration by allowing students to situate new concepts within an evolving conceptual framework. Taken together, the results indicate that when conceptual dependencies and relationships are made explicit, students engage with course content as a network rather than a linear sequence of topics. Across both courses, students described locating new concepts within the evolving graph and tracing relational paths to compare alternatives, suggesting that knowledge graphs can support classroom reasoning by making conceptual relationships visible.

4. Conclusions and implications

Our findings answer both research questions by showing that students perceived instructor-constructed KGs as effective tools for organizing disciplinary knowledge and that these representations supported their ability to articulate relationships among concepts and compare alternative methods or solution strategies. Students reported that KGs helped them visualize dependencies among concepts and understand the broader conceptual structure of the course, reinforcing their role as tools for making relational and hierarchical aspects of STEM content explicit.

Future research could expand the number of participants, enabling more robust statistical analysis and improving the generalizability of the findings. Another direction is to investigate participatory models in which students contribute to the construction or revision of KGs, thereby deepening engagement with disciplinary structure. Overall, the findings suggest that knowledge graphs have the potential to serve as powerful pedagogical representations that make the structure of STEM knowledge explicit and accessible to inquiry.

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DESIGNING FOR LEARNER VARIABILITY AT SCALE: A UDL-ALIGNED FRAMEWORK FOR ASYNCHRONOUS ONLINE TEACHING

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Abstract

Asynchronous online learning expands access to higher education, but it can also magnify barriers related to learner variability, accessibility, and sustained engagement. Universal Design for Learning (UDL) offers a proactive framework for addressing these challenges; however, faculty often lack practical, scalable structures that translate UDL principles into repeatable course design decisions. This paper presents a design-based, practice-informed framework for asynchronous online teaching developed at a public university through collaboration among a centralized online learning unit, the Center for Teaching and Learning, a faculty advisory board, and a pedagogy-focused community. Rather than introducing a standalone initiative, the framework enhances an institutionally adopted guided course design template by embedding explicit UDL expectations at the module level. Core design features include aligned outcomes, multiple means of representation, structured choice in engagement and assessment, and accessibility-by-design practices. The paper describes the framework's institutional context, collaborative development process, and integrated design logic, and discusses its implications for scalable, policy-aligned, and equitable asynchronous online learning.

Keywords: *Universal design for learning, asynchronous online learning, course design frameworks, inclusive pedagogy, faculty development.*

1. Introduction

Asynchronous online learning has become central to higher education, particularly for institutions serving adult learners, working professionals, and geographically distributed students. Its flexibility expands access, but it also increases the importance of course structure, transparency, and navigational clarity because students often work without immediate instructor support. When online courses rely on a single pathway for accessing content or demonstrating learning, barriers can intensify for students with disabilities, neurodivergent learners, multilingual students, and those balancing employment, caregiving, or other external responsibilities (Hodges et al., 2020; Martin et al., 2020).

Universal Design for Learning (UDL) offers a proactive response to learner variability by encouraging instructors to provide multiple means of engagement, representation, and action and expression (CAST, 2018). In higher education, UDL has increasingly been positioned not only as an accessibility framework, but also as an equity-oriented approach to inclusive pedagogy in digital learning environments (Chick et al., 2025; Moriña, 2025). Yet implementation in asynchronous online learning remains uneven. Faculty often value inclusive teaching, but report uncertainty about how to operationalize UDL in ways that are sustainable, aligned to outcomes, and realistic within existing workloads (Altowairiki, 2023; Wells, 2024).

This paper addresses that gap by presenting a design-based, practice-informed framework for asynchronous online teaching that embeds UDL directly into an existing guided course design template. The framework was developed collaboratively through a centralized online learning unit, the Center for Teaching and Learning (CTL), a faculty advisory board, and a pedagogy-focused community. The purpose of this paper is to describe the institutional problem of practice, the collaborative development process, and the design logic of a framework intended to support scalable and equitable asynchronous online learning.

2. Institutional context and development approach

SUNY Empire State University serves a diverse population of adult learners through largely online and asynchronous academic programs. Many students balance academic study with full-time work, caregiving, military service, or other responsibilities. Within this context, asynchronous online learning functions as a primary access mechanism rather than simply an instructional preference.

The institution had already established a centralized online learning unit, Empire Online, that supported course development through an institutionally adopted guided course design template. That template promoted consistency, basic usability, and quality assurance across online courses, but it did not explicitly operationalize UDL. At the same time, CTL faculty development efforts increasingly emphasized inclusive pedagogy, accessibility, and UDL. Faculty often expressed interest in applying these ideas, yet they also raised recurring concerns: how to provide meaningful student choice without increasing workload, how to align flexibility with course outcomes, and how to address accessibility proactively instead of retroactively.

This disconnect constituted the core problem of practice. Inclusive design was valued institutionally, but it was not yet embedded within the standard infrastructure of course design. As a result, UDL implementation depended largely on individual faculty expertise and initiative. To address this challenge, CTL partnered with Empire Online to enhance the existing template rather than create a separate framework. This decision built on familiar faculty workflows, reduced resistance to change, and treated UDL as an expected feature of course design rather than an optional add-on.

The development process was intentionally collaborative. Empire Online instructional designers contributed expertise in learning management system functionality, usability, and accessibility standards. CTL contributed leadership in UDL, inclusive pedagogy, and faculty-facing professional learning. A CTL Advisory Board made up of faculty representatives from different disciplines reviewed proposed elements for feasibility, disciplinary relevance, and academic rigor. In parallel, a Pedagogy and Practice community provided a venue for dialogue about teaching realities, learner needs, and sustainable implementation. Multiple rounds of feedback refined the language, expectations, and examples embedded in the framework.

This collaborative design process aligns with literature showing that sustained pedagogical change is more likely when institutions engage shared governance, communities of practice, and cross-unit expertise rather than relying on isolated innovation (Kezar & Holcombe, 2020; Trust & Horrocks, 2023). By embedding UDL in an established course design tool and developing it through existing institutional structures, the framework sought to move inclusive pedagogy from individual preference to institutional practice.

3. UDL-aligned framework for asynchronous online teaching

The framework translates UDL principles into repeatable course design expectations for asynchronous online teaching. It is not intended as a rigid checklist. Instead, it provides a clear structure within which faculty can exercise disciplinary judgment and preserve academic freedom while still creating more inclusive, transparent, and accessible learning environments. Five interrelated components organize the framework.

First, the framework begins with module-level alignment. Each module includes a concise overview, clear module learning outcomes, and explicit connections among outcomes, resources, discussions, and assignments. This helps students understand why materials matter and how different pathways still support the same expectations. In asynchronous settings, where students self-navigate course spaces and schedules, this level of alignment reduces confusion and supports persistence.

Second, the framework incorporates multiple means of representation. Faculty are guided to include more than one way for students to encounter core ideas, typically through text-based resources, multimedia resources, and interactive or applied materials. These resources are selected to support the same concepts and outcomes rather than functioning as disconnected extras. This design helps students access content through formats that better match their learning needs while preserving conceptual coherence.

Third, the framework supports multiple means of engagement through structured choice. Rather than relying on a single uniform discussion prompt in each module, instructors can offer different prompts that are conceptual, applied, or reflective while aligning all options to the same learning outcomes. This approach increases relevance and learner agency without reducing rigor. It also acknowledges that students may connect most strongly to ideas through theory, professional practice, or lived experience.

Fourth, the framework embeds multiple means of action and expression in assessment. For major assignments, students may choose among formats such as written analysis, multimedia presentation, or applied artifact, provided each option addresses the same outcomes. To preserve fairness and clarity, a common rubric is used across formats. This shifts emphasis away from a single preferred mode of expression and toward demonstrated learning.

Fifth, accessibility is treated as a cross-cutting design principle rather than a separate compliance task. Faculty are supported in using accessible document structure, captioned media, clear navigation, and readable visual design from the outset. In asynchronous courses, where instructional materials are often reused across terms, accessibility-by-design is more sustainable than retroactive accommodation and better aligned with inclusive digital learning.

Taken together, these five components create an integrated system. Alignment provides coherence; varied representation, engagement, and expression create structured flexibility; and accessibility ensures that all pathways are usable. The framework therefore balances consistency of experience with meaningful learner choice. It also addresses a common institutional tension: the assumption that scalable course design requires uniformity. In this model, scalability is achieved not through identical learning experiences, but through shared design logic.

4. Implementation supports and implications

The framework is implemented as an institutional support structure rather than an isolated instructional mandate. Empire Online supports faculty in applying the template, using the learning management system, and addressing accessibility requirements. CTL complements this work through workshops, consultations, and design guides that help faculty connect UDL principles to real course decisions. Because the framework is built into existing course development processes, it reduces the need for faculty to translate abstract principles into practice on their own.

This implementation model has several implications. For teaching and learning, it reframes asynchronous online instruction as intentional learning design rather than content transmission. Structured choice and explicit alignment support learner agency while maintaining common expectations. For faculty development, it offers a practical routine for enacting inclusive pedagogy, making UDL more usable and sustainable. For institutional leadership, it illustrates how online learning units, teaching centers, and faculty governance structures can work together to embed equity into everyday academic infrastructure.

The framework also has implications for how institutions define course quality. Traditional quality assurance models often emphasize standardization, which can conflict with inclusive design. This framework suggests a different approach: consistency in structure can coexist with flexibility in how students access content and demonstrate learning. In this way, equity is advanced through design decisions made upstream rather than through individualized intervention after barriers emerge.

5. Conclusion

Asynchronous online learning increases access to higher education, but access alone is insufficient when course design reproduces barriers to participation. The UDL-aligned framework described in this paper responds to that challenge by embedding inclusive design within an existing institutional course template and supporting its use through collaborative governance and faculty development. Its central contribution is not a new theory of online learning, but a practical model for translating UDL into sustainable institutional practice.

By integrating module-level alignment, multiple means of representation, structured engagement choices, flexible assessment pathways, and accessibility-by-design, the framework offers a scalable approach to learner variability in asynchronous online teaching. It also demonstrates that inclusive pedagogy is most sustainable when it is supported by institutional infrastructure rather than left to individual faculty effort. Future empirical research should examine faculty experiences, student perceptions, and learning outcomes associated with this model; however, even at the design level, the framework provides a transferable approach for institutions seeking to align online course quality, equity, and inclusive teaching.

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INTEGRATING ARTIFICIAL INTELLIGENCE IN CURRICULAR DESIGN FROM PRE-SERVICE TEACHERS' PERSPECTIVES: THE ROLE OF PEDAGOGICAL COMPETENCE

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Abstract

Generative artificial Intelligence (GenAI) is increasingly integrated into modern life, including education, where both students and teachers use it in various ways. This raises important questions about future educators' preparedness to utilize GenAI in key tasks like curricular design. Our research focused on the perspectives of future teachers regarding GenAI's role in educational pathways, conducted at the University of Verona within the primary teacher education program. Participants, during a course on "Active Methodologies and Didactic Technologies," designed an educational unit using GenAI tools (Eduaide.ai or Magic School AI) and reflected on the experience. Qualitative analysis revealed that while students actively engaged in quality control and structure organization using GenAI, they often found the process challenging. They recognized the importance of good prompting and believed pedagogical competence was essential to adapt activities to real-world contexts. The findings emphasize the need for teacher involvement in the GenAI design phase to enhance its effectiveness in classrooms. GenAI can support pre-service teachers by fostering creativity and streamlining lesson planning, but educators must remain critical mediators to ensure the curriculum is pedagogically sound and suitable for primary school students.

Keywords: *AI, pre-service teacher, AI literacy.*

1. Introduction

Artificial Intelligence (AI) is deeply integrated into modern life, present in everyday devices such as smartphones, computers, and tablets, thereby entering the educational landscape. AI, particularly its generative form (GenAI), presents opportunities and risks that the educational field can choose to embrace or reject. These tools involve different grades and students of various ages, reaching until primary school, where specific GenAI designed for children could enhance the acquisition of essential digital skills (Voulgari et al., 2021). To achieve this goal, teachers must be prepared to manage this technology effectively (Velander et al., 2024). GenAI catalyze the redefinition of the teachers' role in a more learner-centered paradigm (Khalil & Alsenaidi, 2024). This innovation requires a new adaptive expertise to integrate its possibilities with teachers' pedagogical skills, thereby transforming GenAI from a generic tool into a professional one, adaptable to the context and students' needs (Sperling et al., 2024). AI literacy must be integrated from the beginning of teachers' education, and this is the reason why pre-service teacher training could be a lush soil. Pre-service teachers are in the middle of their training, composed by both theoretical knowledge and practical experiences (such as internship), which enable them to acquire classroom knowledge and develop teaching skills (Park, 2023). These opportunities make them able to grasp reality and ground the theory into practice. During their educational path, they have the opportunity to explore different teaching methods and design learning paths. This teaching competence could be integrated with GenAI tools (Hu et al., 2024), and, to achieve this, it is essential to investigate their perceptions including their feelings, points of view and perspectives. Understanding the challenges and benefits of this collaboration can promote a positive approach that could facilitate a critical and responsible integration of GenAI in teaching and learning practice (Mah & Groß, 2024).

2. Objective

The research aims to fill that niche, answering the following research question: What is the experience in terms of feelings, perceptions and role of pre-service future teachers when GenAI is utilised in the design phase of educational pathways?

Understanding their views could guide the design of pre-service teachers' courses and the integration of AI literacy. This leads to the creation of informed and equipped professionals who incorporate innovative tools, remaining the leader of the educational process.

3. Design

The research was conducted within the course *Active Teaching Methodologies and Educational Technologies* in the Degree Programme in Primary Education at the University of Verona. The course topics included: (a) active teaching methodologies, key principles and transversal elements; (b) instructional design for active methodologies; (c) guidelines for planning active approaches; (d) the role of technology in teaching practice; (e) educational robotics; and (f) AI in education. Teaching modalities combined lectures with active learning strategies. The research focused on the section of the course devoted to AI and education, which consisted of two sessions of two and a half hours each. This paper reports on the first session, which aimed to provide a theoretical introduction to AI, its historical development, functioning, and integration into educational contexts. Participants were introduced to general-purpose GenAI tools, prompt formulation, and GenAI-based supports for lesson planning. At the end of the session, participants were asked to engage in a collaborative design task. Working in groups of four or five, they were instructed to design a didactic sequence of 6 to 10 hours for either primary or pre-primary school, using one of two GenAI tools proposed, such as Eduaide.AI or MagicSchool.AI, according to their preference. We provided support during the activity process. Fourteen groups were formed: thirteen used MagicSchool.AI, while one selected Eduaide.AI. Upon completion, the groups uploaded their outputs to a shared online platform. Participants were asked to answer six open-ended questions to reflect on their experience and gain awareness of their impressions, thoughts, and processes.

4. Methods

The research sample consisted of participants from the course: approximately 100 students were enrolled, but only 43* attended in person regularly (these participants represent our sample). The responses were unevenly distributed across the six questions: Question 1 (36; students' role), Question 2 (27 responses; interactions with GenAI), Question 3 (25; positive and negative disclosure), Question 4 (23; efficiency and critical points), Question 5 (22; pedagogic and teaching skills), and Question 6 (21; GenAI possible role). For reasons of relevance and analytical depth, this paper reports the analysis and interpretation of Questions 1, 2, and 5, which together provide an overview of pre-service teachers' perceptions regarding the integration of GenAI in lesson planning and highlight the continuing importance of human pedagogical competence in fostering productive collaboration with GenAI. Data were analyzed using Inductive Content Analysis (Elo & Kyngäs, 2008), which allowed categories to emerge directly from participants' responses. This approach was chosen to capture the experience-based perspectives of future teachers as they engage with GenAI tools in a pedagogical design context.

5. Results

This section presents the results of the analysis of the data from the three questions of interest for the paper. The research results outline a complex picture based on the following dimensions: management of the task, experiential interaction, and the critical role of pedagogical competence.

5.1. Roles during interaction with GenAI: A dialogue

The first question was phrased as follows: What was your role during the design work with GenAI? The analysis focused on the role assumed by participants during the activity. From the 43 occurrences detected, a code was generated that highlights two categories: "Input/Output Management" and "Idea Management" (Table 1). There was a clear prevalence of the former (32) over the latter (11). It can therefore be seen that the role of the participants was to lead the interaction in various stages, from conception to the final product, with constant intervention during the process, exercising decision-making powers over form, content, and actions. The students mainly acted as prompt writers (9) and devoted themselves to enriching and improving the generated texts (7), both in terms of content quality and quantity of information to be included. They then performed correction (5) and control (5) functions. Other minor tasks included translation, time alignment of activities, and organization of materials. At the same time, participants also describe themselves as contributors at the level of concept generation (5), sharing proposals within the group (4), as well as sporadic planning and evaluation activities.

*The number of responses varied because students could choose to participate in all or only some.

This scenario as a whole indicates a cycle that determines how interaction takes place: the prompt is the fundamental element for creating a dialogue with GenAI and obtaining possibilities. The prompt serves as a connection between the individual and the machine: it begins with an idea from the individual, gets elaborated on by the machine, and then returns to the user as output. Then this output can, in turn, be modified by new prompts with a continuous exchange between inside and outside the machine. This suggests two directions: if prompting is the key to establishing collaboration, then future teachers must be trained to be effective in this regard; if generation, transformation, and correction of output is necessary, then future teachers need to have a wealth of resources, both internal and external, complementary to those of GenAI, in order to exponentially enhance hypothesis and solutions.

Table 1. Coding Participants' Management in GenAI Interaction.

Category	**Label**	**Count**
Input/Output Management	Prompt Writing	9
	Enrichment and Improvement	7
	Correction	5
	Monitoring/Control	5
	Content Alignment	3
	Translation	1
	Time Alignment	1
	Materials Organization	1
Subtotal		*32*
Idea Management	Generation	5
	Sharing	4
	Evaluation	1
	Planning	1
Subtotal		*11*
Total		43

5.2. GenAI experience evaluation: A polarization

Analysis of participants' experiences (Table 2) reveals a perception of GenAI in an educational design experience as an extremely polarizing tool. We asked them: What was it like interacting with an GenAI tool to design educational activities?

Table 2. Participants' Experience and Perceptions of GenAI Interaction.

Category	**Description**	**Count**
Challenging Interaction	Interaction perceived as demanding or requiring effort	7
Difficulty Interacting	Problems with the interface or software usability	5
Effective Interaction	Constructive and useful interaction	5
Frustrating Interaction	Interaction causing stress or de-humanizing feelings	5
Source of Reflection	Triggers critical thinking on professional skills	2
Sterile Interaction	Interaction perceived as unstimulating	2
Total		26

The most represented category is challenging interaction (7), described as a "fun but tiring" process due to technical issues with the tool or lack of familiarity with the programs. Also significant are the occurrences of frustrating interaction (5) and difficulty interacting (5), with students describing the experience as "dehumanizing," "stressful," or "unintuitive." At the same time, part of the sample experienced effective interaction (5), finding the tool "constructive" and useful for providing "good starting points." The use of GenAI was also a source of reflection (2), triggering fears about the possible replacement of professional training or awareness of the precision required in providing input. For some, the experience was fruitless (2), as they did not recognize any opportunities for learning or professional growth. These results raise many questions. First of all, participants need to learn more about the programs and experiment with them more in order to alleviate frustration and fatigue and reduce difficulties. They need to be given opportunities to do so through structured learning experiences. In fact, interaction has been stimulating in various ways, including reflective and creative aspects; therefore, it is worth investing in

training and systematizing such activities, which should combine an initial theoretical phase focused on the functioning of AI with hands-on activities that apply this knowledge to potential educational designs. Another consideration, however, concerns identity. It is noted that the presence of GenAI in design calls into question the value of a human teacher and, more generally, of humans. This means thinking deeply about how to propose GenAI and offering opportunities to develop awareness of one's personal and professional meaning.

5.3. Pedagogical knowledge and expertise: Foundational elements

The third coding (Table 3) is based on the question: What pedagogical and teaching skills were necessary for working on the proposal?

Table 3. The Role of Pedagogical and Didactic Competence.

Category	Description	Count
Adaptation and Contextualization	Adjusting AI solutions to real school contexts and student needs	12
Conceptual Depth and Quality	Enhancing the educational quality and avoiding superficiality	6
Scientific and Practical Mastery	Using theoretical knowledge to interact with AI	4
Total		22

In this case, it is clear that the students' professional competence was the decisive factor in transforming the GenAI's suggestions into a valid teaching proposal (22). The participants recognize that the skills they have acquired to date serve the purpose of adaptation and contextualization (12). The essential need emerged to make the proposals realistic and flexible, adapting them to the Italian school context, the available resources, and the specific needs of the class. The students, through prompts, had to compensate for the rigidity of the GenAI, calibrating the activities according to the actual school timetable, the age of the children, and the objectives to be achieved. Conceptual depth and quality are also highlighted (6 occurrences). The participants' intervention was necessary to raise the quality of the proposals, which were often judged trivial or superficial from an educational point of view. It is therefore a question of carefully considering the nuances of methodologies, resources, and goals to ensure that the design is wisely guided. Finally, competence brings with it scientific and practical mastery (4). Participants find support for effective planning in their theoretical foundations, methods, and real-life experiences, as well as for skillfully and positively managing their relationship with GenAI, evaluating whether and how to use its suggestions. Overall, the result, already highlighted above, is that students, future teachers, place great value and trust in the knowledge and skills acquired outside the GenAI, entrusting them with the role of guiding design even in new contexts. Considering this idea, we can then reflect on the organization of training plans in which theoretical principles and practical application must be offered in an essential way so as to then promote dedicated opportunities for an enriching exchange with GenAI.

6. Conclusion

The research involved the students enrolled in the course Active Teaching Methodologies and Educational Technologies, included in the Primary Teacher Education program at the University of Verona. The aim was understanding their perspectives toward GenAI use in teaching design phase. Firstly, students emphasize their struggle for a successful and satisfying communication, to the point that some students find it frustrating, linked to the notion of technostress and resistance to change (Mah & Groß, 2024). It is therefore necessary to overcome this obstacle and AI literacy can serve as mitigator for this aim. A deeper knowledge in the more technical aspects of GenAI allows them to interact effectively with the machine (Brandão et al., 2024), reducing technology overload (Muslimin et al., 2023) and put the basis for effective communication, in which teachers direct the tool toward the desired objectives (Sperling et al., 2024). Despite this, even those who show a more positive approach to GenAI emphasise how essential it is to maintain control throughout the process, from the prompting to the machine to the output evaluation. This relates to the concept of a human-in-the-loop considered essential to promote a human-centred mindset where technology expands rather than replaces human agency (UNESCO, 2023). To do this, however, students emphasised that this constructive interaction, would not have been possible without their knowledge and pedagogical skills. This ability allowed them to adapt outputs to the context and make them more flexible (Sperling et al., 2024), leading to a crucial consideration: AI literacy must be included in teacher training programs, but only as a supplement, an enrichment after pedagogical, educational, and didactic skills. Alongside these, reflective practice is structured as a pillar. Thanks to an intentional and systematic inquiry during and after the teaching practice, pre-service teachers can inform future decision-making and restructure their teaching (Sperling et al., 2024). Reflective thinking becomes the vital

catalyst also for a professional identity shift, with which teachers re-evaluate their role, exploring new shape of teaching identity associated to GenAI transformation (Ng et al., 2023). The study therefore contributes by showing that AI literacy is necessary to address basic AI issues, both in technical and pedagogical terms, not only with a theoretical perspective but also with concrete, hands-on activities. This training program be integrated into the training curriculum in a cross-cutting manner, as one of the tools that teachers develop throughout the course. Furthermore, it is necessary to develop reflective skills to adapt and choose appropriately when, where, and how to integrate this tool, ensuring a constructive approach that sees it as a resource rather than an enemy that could replace them. The study has several limitations that future research could address. Firstly, the number of participants is small and restricted to a single context, which prevents generalizations or the possibility of broader implications. Moreover, the research is based on a session lasting only two and a half hours. Due to the limited amount of time, this could represent only an instant perception rather than a significant shift in perspective. Future research should adopt a longitudinal approach with larger, multi-institutional cohorts to examine how pre-service teachers' perceptions of GenAI evolve as they transition from theoretical training to practical classroom implementation. Furthermore, subsequent studies should complement qualitative insights with an objective assessment of the pedagogical quality effectiveness of AI-generated lesson plans to validate the actual impact of human-AI collaboration on student learning.

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EDUCATIONAL PROVOCATIONS IN TEACHING A FOREIGN LANGUAGE: A "SPARK CHAMBER" PROMOTING STUDENTS' CREATIVE LINGUISTIC THINKING

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Abstract

The current concept of creativity is characterized by its multifaceted nature. Creativity may be defined as a set of processes, a creative product (Cropley, 2020), and a competence (Supena, Darmuki, & Hariyadi, 2021; Kolesnikova, Bekk, & Taybe, 2022) closely interrelated with the development of communicative skills and abilities (Jones, 2020). One of them is creative linguistic thinking. Creative linguistic thinking is the ability to use language (not only native, but also foreign) in an original, flexible, and innovative way to create new meanings and communicative forms, both in written and spoken form. Language functions not only as a system of rules, but also as a means to express new ideas and generate meanings, and is integrated into the general concept of creative thinking (Jones, 2020; O. Gafour & W. Gafour, 2020).This insight presupposes the relevance of foreign language teaching practices, which would not only concentrate on the foreign language proficiency, but also emancipate the learner's creative powers. One of such ways is educational provocations (Brown, 2020). Educational provocation can be defined as a purposefully constructed context using various visual aids and written prompts, the purpose of which is to provoke possible thoughts, actions, and verbal activities of the students, motivating them to explore, think (Brown, 2020) and discuss. The research aims to reveal the relations between the educational provocation method and the development of students' creative linguistic thinking. The main research strategy is participatory action research. The research data were collected while examining the observation protocols and researcher's diaries as well as analyzing the materials gained from pupils' oral reflections. The data were analyzed while using the content analysis. The received results allow to state that the educational method of creative provocation is directly related to the development of. students' creative linguistic thinking. Moreover, the educational method of creative provocation increased pupils' curiosity and motivation to perform creative tasks and to use a foreign language actively during the lessons as there were created conditions for the students' self-expression, which revealed in the student's way of expressing their original ideas, and different use of materials.

Keywords: *Educational method of creative provocations, creativity, teaching a foreign language (TFL), creative linguistic thinking.*

1. Introduction

Various definitions of creativity can be identified in academic literature. Creativity can be described as a system of abilities and knowledge that encompasses elements such as finding non-standard solutions and entrepreneurship (Kolesnikova, Bekk, & Taybe, 2022). In the context of 4C, creativity competence is revealed as a skill for implementing a new way of solving a problem, in other words, a completely new and original action. In addition, creativity can also be discussed from three different perspectives. First, creativity can be understood as a set of processes, such as creative thinking; as a set of personal characteristics; and, finally, as a creative product (Cropley, 2020). It should be noted that in general education programs, the following competence components are highlighted in the structure of creativity competence: research, generation, creation, evaluation and reflection.

Another competence that is inseparable from the modern world is the ability to communicate in a foreign language. As Jones (2020) states, most language education researchers recognize that language education should be associated with creativity, whether this is understood as the application of creative didactic practices, the integration of creative texts into the teaching process, or the promotion of students' creative language use. From the point of view of creative thinking theories, creative linguistic expression is inseparable from the ability to generate original ideas, flexibly combine existing linguistic knowledge

and apply them in new communicative contexts (Jones, 2020). According to Kits and Meristo (2025), in language education practice, students often experience difficulties in expressing orally their thoughts creatively. According to Kurtz (2015), Leeming (2017), Milt (2025) these challenges may arise due to linguistic limitations, insufficient self-confidence in using a foreign language, an educational environment focused on such educational goals as the acquisition of grammatical structures and vocabulary, for which reasons the development of originality of ideas and spontaneous linguistic improvisation remains secondary (Kits & Meristo, 2025). Standardized achievement evaluation model. (Stenberg, in Zhao, 2022) can hinder creativity, because creative thinking is unlikely to improve results in these tests. So, teachers, in order to avoid failure in tests, devote more time and attention to their preparation. For these reasons, students may face difficulties in spontaneously expressing their thoughts, choosing instead mechanical memorization or literal translation (Kits & Meristo, 2025).

The development of creativity, as well as creative linguistic thinking, is important, especially in the context of a foreign language, but teachers still lack accessible and practical information on how to develop and promote creativity in a foreign language classroom (Scott–Barrett, Johnston, Denton–Calabrese, McGrane, & Hopfenbeck, 2023). One of the methods to address issues in creative linguistic development is through educational provocations. Educational provocation can be defined as a purposefully constructed context using various visual aids and written prompts, the purpose of which is to provoke possible thoughts and actions of the student and motivate them to explore, think about new ideas (Vecchi, 2013 cited in Porres, 2020; Brown, 2020), and communicate. However, there is relatively little data on the educational application of the educational provocation method the development of students' creative linguistic thinking. Thus, the research aims to reveal the relations between the educational provocation method and the development of students' creative linguistic thinking. The research question is: how is the educational method of creative provocations related to the development of students 'linguistic creative thinking? The object of the study is the connection between students' creative linguistic thinking and educational methods. Research objectives are: to define the concepts of creative linguistic thinking; to substantiate the suitability of the educational provocation method for the development of creative linguistic thinking; to determine the connection between students' creative linguistic thinking and educational provocations; to assess the effectiveness of the educational provocation method in promoting students' creative linguistic thinking. The main research strategy is participatory action research. The purpose of this action research was to improve foreign language teaching practices, in which with the help of educational provocations, each child had a possibility for the development of creative linguistic thinking. The research data were collected while examining the observation protocols and researcher's diaries as well as analyzing the materials gained from pupils' oral reflections. The data were analyzed while using the content analysis.

2. Theoretical reasoning on the interrelation of a creative provocation and the development of students' linguistic creative thinking

Creativity is regarded as one of the core competencies individuals need in the 21st century (González–Salamanca, Agudelo, & Salinas, 2020; Supena, Darmuki, & Hariyadi, 2021), as it is closely related to the concept of "21st century skills" (Lucas, 2016). The Reggio Emilia education system, which can be used to develop children's creativity, is widely described in academic literature. This system is based on the theory of "One Hundred Languages" (Edwards, Gandini &Forman, 2012; The Wonder of Learning, 2017). This theory states that there are many ways to know, feel, create, and express oneself, and that contexts that awaken children's exploration, activity, and creativity, as well as teacher-created provocations, are also important. The aspects of materiality, variability and interaction are important for provocations, which demonstrate the importance of visual and physical arrangement in the educational space and reflect modern trends in optimality and multisensory design for the creation of a learning environment. According to the prevailing approach in the Reggio Emilia education system, the child is at the very center of education and all other supporting tools, such as community, environment, educators, family, art are like helpers, ensuring both the quality of learning and opportunities to develop creativity (Lindsay, 2015). Therefore, this education system is interactive, which is important for developing students' creativity and language learning (Giorgdze & Dgebuadze, 2017). In addition, the Reggio Emilia system is not overly focused on academic achievement or standardization, which allows teachers and students to think flexibly, creatively, and critically. Creating a psychologically safe environment where children are allowed to explore, experiment, communicate and make mistakes (especially using a foreign language) encourages creativity, while an environment that places great emphasis on academic achievement can cause anxiety, pressure, and stifle creativity. In the Reggio Emilia educational system, provocations are crucial for promoting the learning process without error; these activities are understood as a means of stimulating children's creativity, imagination, exploration, free communication (Vecchi, 2013 in Porres, 2020) thus touching upon the opportunities to develop linguistic creative thinking while learning a foreign language.

Linguistic creative thinking is the ability to use language creatively: to generate original ideas, unexpectedly combine words, create meanings, metaphors, stories or new linguistic forms. It includes not only the correct use of language, but also flexible, imaginative thinking in the linguistic medium. This type of thinking manifests itself when a student creates original texts or stories, juggles, plays with words, metaphors, associations, is able to find unexpected linguistic solutions, interprets and conveys thoughts in various styles, creates new constructions, humor or symbolic meanings. An example of a student's speech: instead of the usual sentence "It is raining." the student said: "The sky is quietly melting its gray memories today." This demonstrates students' ability to use language not only to convey information, but also to create emotions, imagery or new meaning. It testifies that it was the environment created by educational provocations which emancipated students' usage of new expressions for their emotions.

3. Methodology

Research methods. The research problem emerged from observations that students were reluctant to complete creative tasks and lacked interesting ideas. Those observations prompted the conducting of action research, during which the educational provocations were practically applied. refine the educational process. The purpose of action research was to improve combined creativity and linguistic creative thinking practices in which each child would feel safe and unique personal ideas without fear of making a language mistake (Clark, Porath, Thiele, & Jobe, 2020). The research data were collected and analyzed using qualitative research methodology.

Data analysis. The guiding questions, stimulating students' reflections were about their changing attitudes towards foreign language classes, how they felt during the prevocational activities, and about the feelings concerning the received results. Their reflections were recorded. Collected data were transcribed and analyzed using inductive qualitative content analysis (Mayring, 2014). The analysis involved repeated reading of interview transcripts, coding meaningful units, developing subcategories and categories. *Research participants* were chosen according to the convenient sampling model and involved the 12 students of the 4th-grade at one of Kaunas X schools in 2025. *Research ethics.* After a cycle of lessons using the provocations and analysis of observations and research reflections, students were suggested on voluntary basis to answer reflexive questions orally. Their reflections were coded from S1 to S10 to provide anonymity.

4. Research results and discussion

In Table 1, categories and subcategories are presented, identified through analysis of the students' reflections after the cycle of the lessons with the practical application of educational provocations.

Table 1. Categories and subcategories from the students' reflections.

No.	Categories	Subcategory	Supporting sentences
1.	Change in attitude towards foreign language classes	*Starting to understand that English is more than learning poems by heart,*	*"We sang the same songs and learnt the same poems as students in 4B, but during the "sparkle class" we tried to create poems by ourselves. It was funny" (S1)*
		English lessons became more interesting.	*"I wait for the English "sparkle class" as we do something extraordinary, for e.g. created sayings about colors" (S2)*
2.	The role of educational creative provocation in foreign language lessons	*Maintaining interest in lessons*	*"We noticed that we are doing something different: making videos for Mother's Day as we considered postcards to be stale. We made interesting texts. My mom liked it" (S3)*
		Arousing curiosity	*"We waited, who would enter the classroom" (S4)*
3.	The significance of the choice of tools/materials for the creative process,	*Providing an opportunity for self-expression*	*"I was happy, when my friends liked my created song" (S5)*
		Giving a possibility to 'do what I want'	*"It was very nice when we did some art in English classes, explained about things happening in English. In short, we could choose what to master and how to explain everything to others" (S6).*

The categories presented in Table1 were identified by analyzing the reflections of 12 students. The category – "Change in attitude towards English lessons", with two subcategories – demonstrates new understanding that language learning is not a monotonous process. Analysis of data collected during students' reflections revealed that some students did not like English lessons very much in the past. Students

got used to routine activities and found them uninteresting. As Vincent–Lancrin et al. (2019) state, to develop students' creativity, it is important to leave room for surprises in lessons. It was the educational method of creative provocations that managed to create surprises, so the students saw that English lessons can be more interesting for them: Also, one of the reasons why the lessons became more attractive for students was the unusual materials: '<...> I was interested in creating songs with special programs <...>.' (S7)

The following category is "The role of educational creative provocation in English lessons", with two subcategories: maintaining interest in lessons and arousing curiosity. From this category, it can be seen that the method of educational provocations helped maintain students' interest throughout the entire lesson cycle, as S8 stated: <...> and I liked it so much that I had to keep myself interested.' Interest was maintained because each time the students were waiting for something unexpected. It was incredibly interesting for me, every day some kind of surprise, like from a calendar.' (S9). It is important to note that the same aspects were observed in both the analysis of observation data and that of students' reflections: increased student interest and aroused curiosity. It was directly linked to motivation to complete a task (Amabile, 1988, in Kaufman & Glăveanu, 2021), and the latter is extremely important in the development of creativity (Beloyianni & Zbainos, 2021) curiosity and creative linguistic thinking (Schutte & Malouff, 2020).

During the analysis of students' reflections, another category was identified – "The significance of the choice of tools/materials for the creative process" with two subcategories: providing an opportunity for self-expression and giving a possibility to 'do what I want'. According to the subjects, the freedom to choose the tools, materials and activities provided an opportunity for their personal self-expression by showing what they liked: <...>, and now it was very good for me, because I could just choose and show what I liked.' (S10). The students also had the opportunity to show their talents. Their presentations had to reflect the goal of the lesson, so they could not exactly do what they wanted, but the ability to choose created a sense of freedom, which is important in the development of creativity and creative linguistic thinking (Guilford, 1950, cited in Taylor, 2023).

Moreover, a change in students' perceptions of creativity English lessons was observed. It is relevant to note that all twelve students, during reflection, named what they learned or understood after the cycle of lessons when the creative provocations method was applied. The first aspect that emerged concerned maintaining originality. The second was related to trying new things. This aspect is important because creativity is related to new, original, non-standard solutions (Forster, 2015). Literature analysis showed that in the Reggio Emilia education system, provocations are significant in stimulating imagination (Vecchi, 2013, in Porres, 2020) and that creativity is directly linked to imagination (Lucas, 2016; Collardo, 2012, in Mazeh, 2020). It is no less important that some students understand that English lessons can be different and interesting. A change in attitude towards their abilities was also detected. This shows that the creative provocations approach influenced students' knowledge of creativity, art, literature, technology, public speaking during English classes. Aspects such as maintaining originality, vivid imagination, and the ability to arouse interest are directly related to the development of creativity.

5. Conclusion

The scientific literature presents multiple concepts and models that reveal different aspects of creativity and creative linguistic thinking. There is no unified definition of the concepts, but it is possible to identify certain aspects inseparable from them. Creativity can and should be developed. In addition, creativity is associated with non-standard, exceptional thinking, an idea that has practical expression and benefits for the environment or the creator. Educational provocations are one of the interactive methods that can foster students' creativity. This method aims to provoke, motivate students, and create room for surprises. This method is also characterized by a variety of tools and activities, which give students the opportunity to choose and experiment not only with familiar materials or texts, but also with unusual, non-routine things. It is important to note that the aesthetic arrangement of tools and linguistic expression is important. When used correctly, educational provocations can develop students' creativity and give them freedom to express themselves by demonstrating their interactive powers.

During the analysis of the action research data, it also became clear that the educational provocations are directly related to the development of students' creativity and linguistic creative thinking as this method piques students' curiosity and interest, which are directly related to the development of creativity and communication. When applying the educational provocations, conditions are created for different students' self-expression, giving them a sense of freedom to be creative personalities.

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BRIDGING SECTORS IN LANGUAGE EDUCATION: A CROSS-SECTORAL COMMUNITY OF PRACTICE APPROACH TO MODERN FOREIGN LANGUAGE IMPLEMENTATION IN IRISH PRIMARY SCHOOLS

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Abstract

Recent curriculum reform in Ireland has positioned Modern Foreign Languages (MFL) as an increasingly significant component of primary education, generating new and evolving professional knowledge demands for teachers. While the Primary Language Curriculum (PLC) and Languages Connect, Ireland's Strategy for Foreign Languages in Education 2017–2026 (DES, 2017) articulate ambitions for continuity across educational phases, opportunities for sustained, dialogic and practical collaboration between primary and post-primary teachers remain limited. Responding to this gap, this study examines the defining features of an effective Cross-Sectoral Community of Practice (CCOP) designed to advance MFL teaching and learning through structured professional dialogue across primary and post-primary contexts. Guided by Communities of Practice theory, the study examines how shared inquiry, peer-observations, collaborative reflection, and reciprocal expertise contribute to teacher learning and pedagogical development. A qualitative design was employed, involving facilitated CCOP sessions with primary and post-primary MFL teachers, supported by reflective prompts and professional artefacts. Data were generated through recorded discussions, reflective journals, focus groups and expertise mapping exercises. Trustworthiness was enhanced through triangulation of data sources, reflective practice, and ongoing participant validation throughout the CCOP process. Findings indicate that effective CCOPs are characterized by relational trust, parity of professional voice, curriculum-informed dialogue, and a focus on pedagogical continuity. Participants reported increased confidence in MFL pedagogy, enhanced understanding of learner progression across curricular phases, and a strengthened sense of collective responsibility for language learning trajectories. Importantly, the CCOP functioned as a space for co-learning, co-designing of resources, challenging traditional hierarchical professional boundaries and fostering sustainable cross-sectoral relationships. The study contributes to emerging research on teacher professional learning in MFL education by identifying sustainable frameworks and design principles for effective cross-sectoral collaboration. It offers practical implications for policy, initial teacher education, and continuing professional development, particularly in systems where primary MFL provision is evolving and requires coherent, teacher-informed support structures.

Keywords: *Modern foreign languages, community of practice, cross-sectoral collaboration, curriculum reform, Irish primary education.*

1. Introduction

Early Language Learning (ELL) (4–12-year-olds) is increasingly recognised for its cognitive, social, cultural, and linguistic benefits (Batardière et al., 2022; Dillon, 2011; Flynn & Singleton, 2025). In the ever-evolving linguistically and culturally diverse classrooms, teachers are expected not only to support language acquisition, but also to foster inclusive and plurilingual learning environments that reflect the realities of contemporary education (Dooley, 2009; Gearon et al., 2009; Ku, 2023). Consequently, the successful implementation of MFL within primary education requires teachers to possess evolving forms of pedagogical knowledge, plurilingual competence and professional confidence.

Recent curriculum and policy developments in Ireland have further elevated the role of languages within primary education. Initiatives such as *Languages Connect: Ireland's Strategy for Foreign Languages in Education 2017–2026* (DES, 2017), the *Primary Language Curriculum* (2019), and the redeveloped *Primary Curriculum Framework* (2023) reflect growing recognition of multilingualism, language awareness, and plurilingual pedagogies within Irish schools. These developments have simultaneously highlighted the increasingly complex teacher knowledge base required to support effective MFL teaching. The *Céim Standards for Initial Teacher Education* and the *Cosán Framework for Teachers' Learning* similarly emphasise the importance of ongoing professional learning and pedagogical expertise in supporting teachers' evolving roles within language education (Teaching Council, 2016).

However, despite these policy ambitions, opportunities for sustained professional collaboration between primary and post-primary teachers in relation to MFL remain limited. Teachers are increasingly expected to move beyond traditional monolingual approaches and act not simply as 'transmitters of linguistic knowledge', but as 'facilitators of language experiences' (Little et al., 2017; Shukhratova, 2025; Shulman, 1987, p. 9). Within this context, CCOPs offer a valuable framework through which teachers can collaboratively share expertise, reflect on practice, and co-construct professional knowledge across educational sectors.

In response to these evolving curricular and professional demands, this study examines the role of a CCOP in supporting teacher professional learning and pedagogical development in MFL. Specifically, the study seeks to explore how participation in a CCOP shapes primary teachers' professional learning and classroom practice in MFL education. The study is guided by the following research questions:

- **RQ1**: How does cross-sectoral participation reshape teachers' perceptions of expertise and professional identity in MFL education?
- **RQ2:** What design features make a CCOP sustainable and meaningful for primary MFL teachers?
- **RQ3:** What barriers and identified solutions affect effective cross-sector collaboration within a CCOP for primary MFL?

The following section outlines the methodological approach adopted to examine the participating teachers' experiences, professional learning, and collaborative engagement within the CCOP, followed by the presentation and discussion of the findings, before concluding with the broader implications of the study for MFL education and cross-sectoral professional learning.

2. Methodology

This study adopted a qualitative interpretivist methodology (Denzin & Lincoln, 2011) to investigate how participation in a CCOP influenced teachers' professional learning, beliefs, and pedagogical approaches in relation to MFL. The methodological approach was informed by Communities of Practice theory (Lave & Wenger, 1991), positioning teacher learning as socially situated, collaborative, and constructed through dialogue, reflection, and shared professional experience i.e 'the domain, the community and the practice' (Wenger-Trayner & Wenger-Trayner, 2015, p. 2). The study sought to privilege teacher voice and lived experience by examining how participants interpreted, negotiated, and reshaped their understanding of MFL teaching within a sustained cross-sectoral professional learning environment.

The CCOP was intentionally designed as a collaborative and dialogic professional learning space in which participants could share expertise, reflect on practice, and co-construct knowledge related to MFL teaching and learning. The structure and design of the sessions reflected Wenger's and Lave's conceptualisation of Communities of Practice through mutual engagement, shared enterprise, and the development of a collective professional repertoire. Consequently, session content focused not only on pedagogical strategies, but also on broader themes including teacher beliefs (Collins et al., 2025; Clayback et al., 2023; Borg, 2011; Orafi and Borg, 2009 Haney et al; 2002) teacher identity (El soussi, 2025; Beijaard et al., 2000), plurilingualism, (Council of Europe, 2022; Council of Europe, 2007; Ollerhead & Choi, 2018) curriculum interpretation, and collaborative problem-solving. Early sessions established shared understandings of key concepts such as teacher knowledge (Shulman, 1987; Connelly & Clandinin, 1988; Tamir, 1991; Ball et al, 2005) and key characteristics of a COP while later sessions encouraged participants to critically reflect on their own professional identities and contextual realities through activities including visual elicitation, collaborative scenario discussions, reflective dialogue, and peer-exchange observations.

Participants were recruited from primary and post-primary schools located within Cork City and county. Recruitment occurred through school principals and a local Education Support Centre, both of whom received formal information regarding the aims and structure of the study before teachers were invited to participate voluntarily. The participant group included both in-service and pre-service teachers from English-medium and Irish-medium educational contexts who demonstrated an interest in language education, plurilingual pedagogies, or MFL teaching. Approximately eight to twelve participants took part in weekly one-and-a-half-hour CCOP sessions over the course of six weeks.

Data generation occurred through multiple qualitative methods designed to capture reflective, collaborative, and experiential dimensions of teacher learning. Initial individual interviews were conducted at the beginning of the study to establish participants' professional backgrounds, perceptions of MFL teaching, and self-positioning in relation to language education. The CCOP sessions themselves formed a central source of qualitative data and consisted of facilitated professional discussions, collaborative tasks, co-design activities, and reflective exercises. Participants engaged in activities such as mapping their 'language journeys' co-constructing peer-observation frameworks, collaboratively designing plurilingual school initiatives, and discussing practical challenges associated with MFL implementation across educational sectors. Peer-exchange classroom observations also formed part of the professional learning process, enabling participants to observe MFL teaching practices across differing educational contexts and learner age groups.

Participants additionally maintained reflective e-journals throughout the study using Microsoft OneNote. These journals documented individual reflections, evolving beliefs, classroom observations, and responses to guided reflective prompts. Visual elicitation activities (Ingram, 2025) were also incorporated to encourage deeper reflection regarding participants' experiences of language learning and teaching. Through the discussion of significant or 'proud' MFL teaching moments, participants explored evolving understandings of confidence, competence, teacher knowledge, and plurilingual identity. Researcher field notes were maintained following each session in order to document contextual observations, group dynamics, and emerging themes throughout the CCOP process.

All interviews, professional dialogues, and focus group discussions were audio-recorded and manually transcribed by the researcher. Data was anonymised at the point of transcription through the use of pseudonyms and securely stored in accordance with GDPR and University ethical guidelines. Trustworthiness was enhanced through prolonged engagement with participants, methodological triangulation, reflective journaling, and ongoing collaborative dialogue throughout the duration of the CCOP. Collectively, the methodology enabled an in-depth exploration of how cross-sectoral collaboration may support teacher professional learning, pedagogical confidence, and plurilingual practice within the evolving landscape of MFL education in Ireland.

3. Findings and discussion

The findings of this study indicate that an effective CCOP in MFL education was characterised by relational trust, parity of professional voice, curriculum-informed dialogue, and sustained collaborative engagement across educational sectors. Over the course of the CCOP, participants increasingly positioned themselves as co-learners rather than as representatives of hierarchical sectors or differing levels of expertise. Professional dialogue developed within a supportive and non-evaluative environment in which both primary and post-primary teachers were encouraged to share pedagogical experiences, challenges, and contextual realities related to MFL teaching and learning. This reciprocal exchange contributed to a greater recognition of the complementary forms of expertise held within each sector. While post-primary teachers frequently contributed specialist subject knowledge and experience in formal MFL instruction, primary teachers shared approaches related to child-centred pedagogy, language awareness, and holistic classroom practice.

Participants reported that the CCOP enhanced their understanding of pedagogical continuity and learner progression across curricular phases. Discussions surrounding curriculum specifications, planning documents, and language learning expectations facilitated greater awareness of how MFL experiences may develop from primary through post-primary education. Cross-sectoral dialogue also enabled participants to critically reflect on how teaching methodologies may require adaptation depending on educational context, learner age, and school setting. Peer-exchange classroom observations emerged as a significant feature of this process. Primary teachers observing post-primary MFL classrooms, and vice versa, provided opportunities to examine contrasting pedagogical approaches, classroom management strategies, target language use, and learner engagement practices. Participants frequently identified these exchanges as professionally valuable due to the practical insights gained into unfamiliar educational environments and teaching approaches.

The co-construction of professional resources and reflective tools further contributed to the collaborative nature of the CCOP. Participants collectively designed observation sheets tailored to their own professional interests and MFL-related needs, with emphasis placed on areas such as classroom climate, plurilingual practices, learner participation, teaching methodologies, and target language use. This collaborative design process reinforced participant agency within the CCOP and ensured that professional learning activities remained contextually relevant and participant-informed. Similarly, participants engaged in collaborative discussions regarding the development of inclusive school language policies informed by the work of Little & Kirwan (2024). These discussions focused on the practical implementation of plurilingual approaches within schools, including the establishment of plurilingual committees, the visibility of home languages within school environments, and the creation of structures intended to celebrate linguistic and cultural diversity. The practical dimensions of these activities contributed to participants' perceptions of the CCOP as professionally meaningful and applicable to their own educational contexts.

The findings also indicate that the CCOP functioned as a significant space for reflective professional identity work. Structured reflective activities encouraged participants to critically examine their evolving roles as language educators within increasingly plurilingual educational settings. Activities such as 'My Language Journey' and visual elicitation tasks facilitated deeper exploration of participants' personal and professional experiences of language learning and teaching. Through the discussion of significant or 'proud' MFL teaching moments, participants engaged in authentic reflection regarding confidence, competence, and professional growth. These activities frequently generated more detailed and emotionally grounded reflections than traditional discussion-based tasks, enabling participants to articulate evolving understandings of teacher knowledge, plurilingual identity, and professional expertise.

Across the duration of the CCOP, participants reported increased confidence in MFL pedagogy and a strengthened sense of collective responsibility for language learning trajectories across educational phases. The collaborative and dialogic nature of the CCOP challenged traditional professional boundaries between sectors and promoted greater recognition of shared educational aims within MFL education. Furthermore, the findings suggest that sustainable CCOPs require structured opportunities for reflection, practical collaboration, participant voice, and sustained cross-sectoral engagement. The integration of peer-observation, collaborative problem-solving, reflective journaling, curriculum-informed dialogue, and co-designed professional activities contributed to the development of a professionally meaningful learning community capable of supporting both individual and collective pedagogical development.

4. Conclusion

This study examined the role of a CCOP in supporting teacher professional learning and pedagogical development within the evolving landscape of MFL education in Irish primary schools. The findings demonstrate that sustained cross-sectoral collaboration can provide a meaningful and professionally relevant space through which teachers collaboratively negotiate expertise, reflect on practice, and develop greater confidence in MFL pedagogy. The CCOP enabled participants to engage in reciprocal professional learning that challenged traditional hierarchical distinctions between primary and post-primary education while simultaneously promoting a stronger sense of pedagogical continuity across curricular phases.

Importantly, the study highlights that effective CCOPs are characterised not solely by professional dialogue, but by relational trust, participant agency, collaborative problem-solving, and opportunities for sustained reflective engagement. Activities such as peer-observation, co-designing professional resources, reflective journaling, and visual elicitation facilitated deeper exploration of teacher identity, plurilingualism, and professional knowledge within contemporary language education contexts.

As Ireland continues to progress toward greater MFL integration within primary education, the findings suggest that teacher-informed, collaborative professional learning structures may play a significant role in supporting sustainable implementation. More specifically, the study provides practical insights into the development of a future sustainable and replicable framework for CCOP within the MFL space. In doing so, the research contributes to emerging discussions surrounding teacher professional learning, plurilingual pedagogies, and curriculum reform by identifying key design features capable of supporting coherent, reflective, and collaborative approaches to language education across educational sectors.

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THE FUTURE OF UNIVERSITY EDUCATION: TRANSFORMATION, DISRUPTION AND ADAPTATION TO 2040

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Abstract

Higher education is undergoing significant transformation driven by technological change, demographic shifts, economic pressure, and evolving societal expectations. This paper examines the future of universities toward 2035-2040, drawing on recent research and sector analysis. It argues that universities are unlikely to disappear but will persist in transformed forms through processes of adaptation. Key developments include the integration of artificial intelligence and digital learning, the expansion of alternative credentials, the growth of entrepreneurial and interdisciplinary education, and increased emphasis on student experience and public value. Universities most likely to endure will be those that preserve core functions while adopting more flexible, digitally supported, and socially embedded models.

Keywords: *Higher education transformation, artificial intelligence, alternative credentials, entrepreneurial universities, student experience.*

1. Introduction

The future of university education is increasingly shaped by technological disruption, financial pressure, demographic change, and heightened expectations regarding public value. While claims about the "end" of universities persist, current evidence suggests not disappearance but restructuring and differentiation (OECD, 2024; Arthur D. Little, 2024; Peck et al., 2025).

This paper argues that universities will endure through **adaptive transformation**. Institutions most likely to remain relevant will preserve core functions – earning, knowledge creation, credentialing, and mentorship – while redesigning how these are delivered. Three claims guide the analysis:

(1) universities will persist as social institutions;
(2) the sector will become more diverse rather than convergent;
(3) adaptive evolution offers the most convincing framework for institutional response.

This study is conceptual and literature-based, drawing on OECD, policy, and sector reports to identify plausible trajectories rather than deterministic predictions.

2. Pressures reshaping the university

The pressures reshaping the university do not operate in isolation. Financial strain, technological disruption, demographic change, and questions of public legitimacy are mutually reinforcing and together create the conditions under which institutional adaptation becomes necessary rather than optional. Among these, financial fragility and policy pressure are useful starting points because they shape universities' capacity to respond to influencing staffing, student support, digital investment, and the scope for strategic experimentation.

2.1. Financial fragility and policy pressure

The post-war settlement that supported mass higher education has weakened. For decades, universities expanded under a relatively stable logic: public investment justified by human capital arguments, strong student demand, aligned research funding, and international recruitment as an additional revenue source. Recent analyses suggest this model is now under strain. OECD data indicate that higher education funding has stagnated or declined in real terms across several systems (OECD, 2024).

The consequence is not only a temporary shortfall but a structural sustainability problem. Universities face rising costs, limited productivity gains in labor-intensive teaching and research, and exposure to volatility in international recruitment (KPMG, 2020; Arthur D. Little, 2024). Jisc and KPMG highlight pressures for shared services, consolidation, and new operating models, while Peck et al. note that around 40% of UK institutions are in deficit (Jisc & KPMG, 2024; Peck et al., 2025). Financial pressure therefore does more than reduce budgets: it forces institutions to clarify mission, differentiate their offer, and reassess whether inherited organizational models remain viable.

2.2. AI and digital learning

AI has intensified these pressures by challenging the assumption that universities derive value primarily from controlling access to information and expert explanation. Generative AI tools are rapidly embedded in student and staff practice. KPMG Canada reports that 59% of students surveyed were already using such tools, while the literature increasingly treats AI as a system-level force affecting teaching, assessment, and governance (KPMG Canada, 2025; Higher Education Digest, 2025; Shane & ChatGPT, 2025). Universities organized around information transmission are therefore exposed to comparison with low-cost, always-available digital tools. This does not imply obsolescence. Rather, it sharpens the distinction between information access and higher learning. As routine tasks become easier to automate, universities are pushed toward less commodifiable functions: critical judgement, ethical reasoning, interdisciplinary synthesis, supervised inquiry, and authentic assessment (Peck et al., 2025). AI thus destabilizes older pedagogic routines while clarifying the continuing importance of human academic work.

The literature also highlights constructive uses of AI. Institutions are experimenting with adaptive learning, predictive analytics, and more responsive support systems (Higher Education Digest, 2025). However, risks remain significant, including bias, surveillance, opacity, and potential deskilling. The future of university education will therefore depend less on simple adoption and more on how AI is governed to support learning while maintaining standards and trust.

2.3. Demographic change, student diversification, and legitimacy

Demographic and social change intensify the need for redesign. In several developed systems, declining birth rates are altering the size and composition of the undergraduate population (OECD, 2024; Peck et al., 2025). At the same time, student populations are becoming more diverse, with increasing emphasis on lifelong and intermittent participation (Towards 2035 Project, 2023).

These shifts challenge the dominance of the full-time, residential model. Future learners are more likely to balance work, care, and financial constraints, and to prioritize flexibility, clear outcomes, and effective support (Arthur D. Little, 2024). A related issue is legitimacy. Evidence points to declining confidence in the value of degrees and concerns about work-readiness. While this does not indicate a general loss of value, it suggests that universities can no longer assume automatic legitimacy. To remain compelling, institutions must demonstrate more clearly their contribution to student development, social mobility, community wellbeing, and forms of knowledge not easily sustained by markets.

3. Emerging trajectories to 2040

If the previous section identified pressures destabilizing inherited university models, the next step is to consider how institutions are already responding. The most plausible futures are not abstract possibilities but trajectories visible in policy, organizational experiments, and sector practice. The discussion begins with alternative credentials and lifelong learning, which most clearly illustrate how universities are rethinking the form, pace, and accessibility of higher education.

3.1. Alternative credentials, modularity, and lifelong learning

One of the clearest signals of structural change is the expansion of alternative credentials. UPCEA reports that 94% of higher education institutions in the United States now offer such credentials, many in stackable form, while OECD analyses position micro-credentials as key to lifelong learning systems (UPCEA, 2023; OECD, 2021). This does not signal the disappearance of the degree, but its repositioning within a broader ecosystem of certified learning that includes short courses, badges, and work-integrated programs. This shift is both economic and pedagogic. Shorter credentials reduce cost and time barriers, support reskilling, and provide intermediate milestones for learners unable to commit to full programs. They also reflect a different conception of educational time: learning becomes episodic, cumulative, and portable rather than front-loaded. Importantly, stronger institutional responses integrate these credentials with degrees, credit recognition, and flexible progression routes (Arthur D. Little, 2024; Zafar, 2025). In such models, learners can move between work and study while accumulating recognized credit. Examples outside traditional universities demonstrate that aspects of skills signaling are increasingly contestable, and institutions that ignore this risk losing educational ground.

3.2. Entrepreneurial education and interdisciplinary innovation ecosystems

A second trajectory is the rise of entrepreneurial and innovation-oriented university models. Here, the entrepreneurial university is not simply one that commercializes research, but one that reorganizes teaching, knowledge exchange, and engagement around problem-solving and collaborative value creation (Cheng et al., 2025). This shift brings interdisciplinary collaboration closer to the center of institutional design. Complex challenges such as climate change or digital governance require approaches that cut across disciplinary boundaries, often organized through challenge-based learning and collaborative projects (McCoy, 2025).

Entrepreneurial universities also reposition students and staff as potential innovators rather than passive participants. Policies around ownership, incubation, and partnerships shape whether such activity

is enabled, while spaces such as incubators and maker environments are becoming more central (Zafar, 2025; Davey et al., 2025). This trajectory also has a public dimension. Beyond commercial activity, it includes co-designed curricula, community engagement, and research linked to regional development. In this sense, entrepreneurial education can strengthen, rather than weaken, the public role of the university.

3.3. Digital-first and blended institutional forms

Universities are also becoming more digital by design, while retaining physical campus functions. Although accelerated by recent disruptions, this shift now reflects a longer-term structural change. Many institutions are moving toward digital-first models in which online delivery is a core infrastructural layer (Arthur D. Little, 2024; Peck et al., 2025). This does not imply fully virtual universities. Instead, it reshapes the division of labor between online and in-person learning. Content delivery can occur asynchronously, while campus time is used for discussion, laboratory work, mentoring, and collaboration. This model allows more purposeful use of physical space while increasing flexibility. Digital forms are particularly relevant for diverse student populations, including those balancing work, care, or geographic constraints (Towards 2035 Project, 2023). However, limits remain: many disciplines still require embodied and supervised learning. The likely outcome is not the disappearance of the campus, but a more selective and intentional one within a broader digital system.

3.4. Student experience as strategic infrastructure

Student experience has shifted from a peripheral concern to a strategic one. Financial pressure, demographic change, and value scrutiny mean that universities are increasingly evaluated by progression, support, employability, and overall learning coherence. McCoy's framework highlights the connection between learner needs, institutional design, and organizational effectiveness (McCoy, 2025). Its importance lies not in consumer satisfaction but in supporting diverse learners. Flexible entry points, clearer pathways, and integrated academic and pastoral support are increasingly necessary. While AI may assist with early intervention and routine support, the literature emphasizes the continued importance of human mentorship and community. As confidence in degrees is questioned and costs rise, universities must demonstrate that learning is meaningful and developmental. Student experience is therefore not a peripheral issue, but a central component of institutional legitimacy and survival (KPMG, 2020; Peck et al., 2025).

4. Why adaptation is more plausible than disappearance

These trajectories raise a larger analytical question: do they signal the erosion of the university as a distinctive institution, or its transformation into new but recognizable forms? The argument advanced here is that adaptation is more plausible than disappearance, but this requires a clearer account of what is worth preserving. It is therefore necessary to begin with the core functions of the university, since institutional survival depends less on preserving inherited structures than on sustaining the enduring purposes universities serve.

4.1. Preserving the core functions of the university

The claim that universities are likely to survive depends on whether their core functions remain socially necessary. The literature suggests that they do. First, universities continue to provide recognized credentialling and standards of achievement. Second, they offer access to infrastructure and organized expertise that are difficult to replicate at individual level. Third, they remain important sites of mentorship, social formation, and identity development, as learning is not exhausted by content delivery but also involves community, challenge, and feedback. Fourth, universities continue to produce and curate knowledge. While market and non-profit actors contribute to innovation, universities retain a distinctive role in longer-horizon inquiry, disciplinary renewal, and the preservation of knowledge (KPMG, 2020; OECD, 2024). These functions are not always directly profitable, which makes them vulnerable if reduced to market logic alone.

4.2. Adopting new models without surrendering purpose

If these functions remain valuable, the question becomes how they will be sustained. The literature points not to stasis but to redesigned forms: hybrid delivery, modular structures, stackable credentials, challenge-based curricula, and new partnerships (OECD, 2021; Arthur D. Little, 2024; Jisc & KPMG, 2024). The survival of universities is therefore best understood as the reorganization of enduring functions through new institutional forms.

This distinction resolves a false binary in higher education debates. Universities do not need to choose between preserving tradition unchanged and abandoning their identity. What is required is a more selective understanding of what is essential. Lectures, semester structures, and rigid disciplinary boundaries are historically familiar but not equivalent to the university's fundamental purposes. By contrast, intellectual formation, inquiry, mentorship, and public contribution are closer to those purposes.

Adaptation becomes persuasive when it preserves the latter while redesigning the former.

The claim is not that all universities will survive in their current form. Some will merge, narrow their mission, or fail. Nor is it that all reforms will succeed. Rather, the most plausible future is one of differentiated continuation: universities persist by changing shape, and those most likely to succeed can distinguish core functions from inherited routines.

4.3. Interdisciplinarity, community, and the renewed public role

Literature supports a stronger version of the adaptation argument: universities are more likely to remain legitimate when they reconnect internal transformation to a renewed public role. Institutions are increasingly asked to justify their value beyond enrolment volume or rankings. Interdisciplinary collaboration is central to this role. Many challenges universities are expected to address – health inequality, sustainability, digital ethics, urban resilience – cross disciplinary boundaries. Institutions organized as loose federations of departments may struggle to respond, while challenge-based and cross-sector approaches allow them to demonstrate relevance without reducing complexity (Cheng et al., 2025; McCoy, 2025).

A community-centered role also requires universities to act less as detached providers and more as embedded civic actors – building relationships with employers, government, schools, and communities, and treating community knowledge as an input into research and teaching. This orientation is not opposed to academic mission; it strengthens the basis on which universities claim support, trust, and autonomy.

5. Adaptive evolution as a strategic framework

The framework of adaptive evolution, developed by McCoy, offers a useful way to organize the implications of the preceding analysis. Its value lies in treating institutional transformation neither as linear modernization nor as episodic crisis management. Instead, it describes a mode of change in which universities preserve mission while developing the capacity to redesign structures, experiment with alternatives, and learn from results (McCoy, 2025).

5.1. Recentring

The first move is recentering: returning institutional attention to mission, student need, and operational clarity. In practical terms, this involves identifying which activities are central to educational value, which cost structures remain sustainable, and where student progression is hindered by avoidable friction (McCoy, 2025). Conceptually, recentering matters because it prevents change from becoming indiscriminate. Universities that innovate without clarity of purpose risk multiplying initiatives without improving coherence.

5.2. Catalyzing

The second move is catalyzing. Universities need protected spaces in which new models can be tested without being forced into the assumptions of the legacy institution. This is particularly important for modular programs, new credential forms, and alternative partnership structures (McCoy, 2025). A recurring theme is that innovation fails when required to fit governance cycles, quality procedures, or staffing models designed for older forms of provision. Catalyzing therefore involves both experimentation and institutional protection.

5.3. Enabling

The third move is enabling: building the organizational conditions in which adaptation can be sustained. This includes leadership development, staff capability, digital infrastructure, revised metrics, and a willingness to learn from partial failure (McCoy, 2025; Peck et al., 2025). It also requires governance systems that can move at an appropriate pace while maintaining academic legitimacy. Universities may know what they need to change yet lack the structures or incentives to do so.

Taken together, these three moves explain why some universities are more likely to endure than others. Institutions that only cut costs may stabilize temporarily but lose legitimacy, while those that digitize indiscriminately may weaken what makes them distinctive. Adaptive evolution is persuasive because it links innovation to mission, experimentation to governance, and students need to institutional design.

6. Discussion

The argument developed here does not support a simple narrative of either continuity or disruption. Universities are unlikely to remain unchanged, but neither are they likely to disappear as a social form. The more convincing picture is one of selective continuity through structural transformation.

The claim that universities will survive through adaptation is strongest when grounded in documented trends. Recent literature highlights several anchors: the expansion of alternative credentials, AI experimentation, changing student demography, pressures for consolidation, and growing entrepreneurial and partnership activity (UPCEA, 2023; KPMG Canada, 2025; Jisc & KPMG, 2024; Cheng

et al., 2025; Peck et al., 2025). While these developments do not guarantee institutional success, they support a more precise claim: the likely future is not disappearance, but uneven restructuring around institutions able to combine durable academic purposes with flexible, digitally enabled, and publicly accountable forms.

This conclusion should still be held cautiously. The evidence base remains shaped by sector reports and early examples rather than long-term evaluation, and trajectories will depend on national regulation, funding, and political choices. The contribution of this article is therefore interpretive rather than predictive, identifying plausible directions rather than guaranteed outcomes.

7. Conclusion

By 2035-2040, university education is likely to be more modular, digitally mediated, entrepreneurial, and more explicitly judged in relation to student outcomes and public value. Students may move in and out of higher education across the life course, combining different forms of credentialled learning and engaging with AI-supported teaching and support (OECD, 2021, 2024; Arthur D. Little, 2024). Physical campuses will remain important, but less as default sites of information delivery and more as spaces for laboratory work, mentoring, collaboration, and community (Peck et al., 2025).

Institutions most likely to remain consequential will be those able to protect what is distinctive about the university while redesigning what is historically contingent. They will preserve core functions—rigorous learning, knowledge creation, credentialling, and human development – while adopting new models of delivery, assessment, partnership, and governance. Interdisciplinary collaboration, flexible credentials, digitally supported learning, and stronger community engagement are therefore becoming central conditions of institutional relevance (Cheng et al., 2025; McCoy, 2025; Zafar, 2025).

The future of university education is neither straightforward decline nor seamless innovation, but a process of adaptation. Universities will remain necessary institutions, but their legitimacy will depend on how effectively they connect enduring academic purposes to the demands of a changing society. The university of 2040 is most likely to endure not by becoming less of a university, but by becoming more explicit, flexible, and accountable in fulfilling its public role.

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A DATA-DRIVEN, INCLUSIVE AND STUDENT-CENTRED MODEL FOR ENGAGEMENT, BELONGING AND SUCCESS IN HIGHER EDUCATION

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Abstract

Student engagement and continuation remain critical challenges for higher education, particularly in the post-pandemic context where traditional indicators often fail to capture the complexity of learners' experiences (Collins, Dooley & O'Brien, 2022). Many institutions continue to rely on retrospective data to identify students at risk, limiting the timeliness and effectiveness of support. This paper presents an innovative, data-driven and student-centred model designed to enhance engagement, belonging, and academic success across undergraduate and postgraduate programmes.

The model utilised weekly monitoring of virtual learning environment (VLE) activity to identify low-engaged students and facilitate targeted interventions. Initial implementation resulted in a 28% increase in online engagement during the first trimester and a 41% increase during the second trimester compared with the previous academic year. The framework subsequently evolved into a comprehensive student-success model incorporating academic-skills development, peer mentoring, and dedicated student-success coaching. Outcomes included improved submission rates, enhanced continuation, and a reduction in attainment disparities. The paper argues that combining data-informed decision-making with personalised and inclusive support can significantly improve student outcomes and strengthen students' sense of belonging within higher education.

Keywords: *Student engagement, inclusive education, data-driven intervention, continuation and progression, equity and belonging.*

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1. Introduction

Student success has become a central priority within higher education institutions worldwide. Increasing diversity within student populations, rising mental health concerns, and the lingering effects of the COVID-19 pandemic have created new challenges for universities seeking to support student engagement and retention. Traditional approaches to student support often rely on reactive interventions that occur only after academic difficulties become evident. Such approaches frequently fail to address underlying issues affecting student participation, confidence, and belonging.

Research consistently demonstrates that student engagement is strongly associated with academic achievement, continuation, and overall student satisfaction (Kahu & Nelson, 2018). Equally important is students' sense of belonging, which has been identified as a significant predictor of persistence and success in higher education (Thomas, 2012). Institutions therefore require proactive strategies capable of identifying disengagement early and providing timely support before challenges escalate.

This paper presents a data-driven, inclusive, and student-centred model developed and implemented in the Faculty of Business and Law at Anglia Ruskin University (ARU). The initiative was designed to enhance student engagement, foster a stronger sense of belonging, and improve academic success through the integration of learning analytics, personalised interventions, peer support, and academic-skills development. Evidence from its implementation demonstrates significant improvements in student engagement, continuation rates, and equity outcomes, highlighting the potential of holistic and proactive support frameworks within higher education.

2. Literature review

Student engagement has long been recognised as a multidimensional concept encompassing behavioural, emotional, and cognitive dimensions of learning (Fredricks, Blumenfeld & Paris, 2004). Contemporary higher education environments generate substantial digital data through learning management systems, creating opportunities for institutions to better understand patterns of student participation and engagement.

Learning analytics has emerged as a promising approach to supporting student success. By analysing data generated through student interactions with digital learning platforms, institutions can identify students at risk of disengagement and implement targeted support measures (Siemens & Long, 2011). However, critics caution that analytics alone cannot address the complex social and emotional factors influencing student outcomes (Prinsloo & Slade, 2017).

The concept of belonging has gained increasing attention within student-success literature. Thomas (2012) argues that students are more likely to persist when they feel connected to their academic community. Belonging is particularly important for students from underrepresented backgrounds, who may experience additional barriers to engagement and achievement.

Inclusive approaches to student support seek to reduce barriers while recognising the diverse needs of learners. Such approaches move beyond deficit-based models that focus solely on students' weaknesses and instead emphasise strengths, empowerment, and community building (Ainscow, 2020). Integrating learning analytics with inclusive and relational support mechanisms therefore offers significant potential for improving student outcomes.

3. The centre for student success: An institutional approach to student engagement and success

The model was initially developed in response to growing concerns regarding student engagement, retention, and continuation within the Faculty of Business and Law at Anglia Ruskin University. Analysis of institutional data revealed that many students who eventually withdrew or underperformed had shown signs of disengagement much earlier in the academic year. However, existing support mechanisms relied heavily on traditional indicators such as attendance records, assessment submissions, and end-of-module outcomes. While these measures provided useful information, they were often retrospective in nature, identifying issues only after students had already disengaged from their studies or reached a point where intervention was less effective.

This reactive approach presented several challenges. Attendance data alone did not fully capture student engagement, particularly in an increasingly digital learning environment where students interact with course materials, peers, and staff through multiple channels. Similarly, module results and assessment outcomes often served as lagging indicators, highlighting problems only after academic performance had already been affected. As a result, opportunities for early intervention were frequently missed, limiting the institution's ability to provide timely and personalised support.

Recognising these limitations, the faculty sought to develop a more proactive and evidence-based approach to student success. The aim was to move beyond retrospective measures and utilise real-time engagement data to identify students who may be at risk of disengagement before academic difficulties emerged. Drawing upon learning analytics from the virtual learning environment (VLE), the model enabled weekly monitoring of student activity patterns, including access to learning materials, participation in online activities, and overall engagement with their programme of study. Students demonstrating low levels of engagement were identified early and contacted through personalised interventions, allowing support to be offered at a stage when it could have the greatest impact.

The development of this model marked a significant shift from a reactive to a preventative approach to student support. Rather than waiting for students to miss assessments, fail modules, or formally withdraw, the faculty adopted a strategy centred on early identification, meaningful engagement, and targeted intervention. This approach recognised that student success is influenced by a complex combination of academic, personal, social, and motivational factors, and that timely support is essential in helping students overcome barriers to progression and achievement.

3.1. Early identification through learning analytics

The first phase involved systematic monitoring of student activity within the VLE. Engagement data were reviewed weekly, enabling the identification of students demonstrating low levels of online participation. Students identified as potentially at risk received personalised contact from academic staff, including emails, telephone calls, and invitations to support sessions.

This proactive approach shifted intervention from a reactive to a preventative model. Rather than waiting for students to fail assessments or withdraw, support was provided at an earlier stage when challenges could still be addressed effectively.

3.2. Academic skills and peer support

Following initial success, the model expanded to include structured academic-skills provision and peer-led support. Postgraduate students were recruited as mentors and worked alongside academic staff to deliver workshops, writing retreats, assessment guidance sessions, and resit support activities.

These initiatives created collaborative learning environments where students could seek assistance without fear of judgement. Peer mentors provided relatable role models while helping students navigate academic expectations and university processes.

3.3. Dedicated student success coaching

The final stage introduced dedicated student-success coaches who provided personalised support to students across multiple campuses. Coaches engaged proactively with students experiencing academic, personal, or engagement-related challenges.

Working alongside academic staff, professional services, and peer mentors, success coaches helped students access appropriate support while maintaining regular contact throughout their academic journey. This created a coordinated and holistic support network focused on enhancing student success and wellbeing.

4. Outcomes and impact

Implementation of the model generated substantial improvements across several key performance indicators.

4.1. Enhanced student engagement

The most immediate impact was observed in levels of student engagement. During the first year of implementation, VLE activity increased by 28% during the first trimester and by 41% during the second trimester compared with the previous academic year.

These findings suggest that regular monitoring combined with personalised outreach can significantly influence student participation. Students who may otherwise have been disengaged were identified early and encouraged to reconnect with their studies.

4.2. Improved assessment participation

Coursework submission rates increased by 9% following implementation. Improved participation is particularly significant because assessment engagement is often a strong predictor of continuation and academic success.

The increase suggests that students benefited from the combination of proactive support, academic-skills development, and peer mentoring opportunities. Students reported greater confidence in approaching assessments and improved understanding of academic expectations.

4.3. Increased continuation rates

Continuation rates within the Faculty of Business and Law (FBL) at Anglia Ruskin University reached 95% in 2023–24, representing the highest level achieved in recent years. This outcome is particularly significant given the sector-wide challenges facing higher education institutions, including declining student engagement, increasing financial pressures, and growing concerns around student retention and progression.

The improvement in continuation rates suggests that early identification of disengagement, combined with proactive and sustained support, can positively influence students' decisions to remain enrolled and successfully progress through their programmes. A key feature of this approach was the establishment of the Centre for Student Success (CfSS), which was launched within the Faculty of Business and Law in September 2022. The Centre was created to provide a coordinated and evidence-based framework for supporting students through early intervention, academic-skills development, engagement monitoring, peer support, and personalised pastoral guidance.

Continuation rates within FBL have shown a sustained upward trajectory since the introduction of the Centre for Student Success. Continuation increased from 89.2% in 2020–21 to 95.0% in 2023–24, before remaining above 93% in subsequent years. While continuation rates also improved across other faculties during the same period, the rate and scale of improvement within FBL were notably stronger. This

is particularly noteworthy because FBL was the only faculty at ARU operating a dedicated Centre for Student Success during this period.

The comparative faculty data provides additional evidence of the effectiveness of the CfSS model. Whereas continuation rates in other faculties generally improved gradually over time, FBL experienced a more substantial increase following the implementation of the Centre. Although it is not possible to attribute all improvements solely to the CfSS initiative, the timing and consistency of the upward trend strongly suggest that the Centre played a significant role in enhancing student engagement, fostering a sense of belonging, and supporting student persistence.

The findings indicate that a structured, proactive, and student-centred approach to support can have a measurable impact on continuation outcomes. By identifying students at risk of disengagement early and providing timely interventions, the Centre for Student Success has contributed to creating an environment in which students feel supported, connected, and more likely to continue their studies successfully.

4.4. Reduction in equity gaps

One of the most significant outcomes was the reduction in the ethnicity award gap to 13%, exceeding institutional benchmarks. This finding highlights the potential of inclusive support frameworks to address disparities in student outcomes.

Rather than focusing solely on specific demographic groups, the model adopted a universal yet personalised approach, ensuring all students had access to support while allowing targeted intervention where necessary.

4.5. Student experience and belonging

While quantitative outcomes provide important evidence of effectiveness, qualitative feedback offers additional insights into the student experience.

Students consistently reported appreciating proactive contact from staff. Many described outreach communications as demonstrating that the university cared about their success and wellbeing. This sense of being noticed and valued contributed positively to students' confidence and motivation. Workshops, writing retreats, and peer-led activities also fostered opportunities for students to build relationships with peers and staff. These interactions contributed to a stronger sense of community and belonging.

The findings support existing literature suggesting that belonging is not simply a by-product of academic success but a key factor contributing to positive student outcomes. Students who feel connected to their institution are more likely to engage, persist, and succeed.

4.6. Discussion

The success of the model demonstrates the value of combining data-driven approaches with human-centred support mechanisms. Learning analytics provided the means to identify students requiring support, but meaningful impact was achieved through personalised interventions and relationship-building activities.

The model challenges the notion that technology alone can solve student-engagement challenges. Instead, technology serves as an enabling mechanism that allows institutions to direct support where it is most needed. Human interaction remains central to effective intervention.

Furthermore, the framework highlights the importance of adopting a holistic perspective on student success. Academic achievement, wellbeing, engagement, and belonging are closely interconnected. Institutions seeking to improve continuation and progression should therefore consider integrated approaches that address multiple dimensions of the student experience. The model also offers a scalable solution for institutions operating across multiple campuses and diverse student populations. By combining centralised data monitoring with localised support provision, universities can create responsive systems capable of meeting varied student needs.

5. Conclusion

This paper has presented a data-driven, inclusive, and student-centred model developed within the Faculty of Business and Law at Anglia Ruskin University to enhance student engagement, belonging, continuation, and academic success. By combining learning analytics with personalised interventions, academic-skills provision, peer mentoring, and dedicated student-success coaching, the model has demonstrated measurable improvements across a range of key student-success indicators, including engagement, coursework submission rates, continuation, and equity outcomes.

The findings suggest that student success is most effectively supported when institutions move beyond reactive approaches and adopt proactive, preventative, and relationship-based models of support. While learning analytics provided the mechanism for identifying students at risk of disengagement, it was the human-centred interventions and sustained personalised support that translated data into meaningful outcomes. This reinforces the importance of viewing student engagement not simply as a measure of activity, but as a reflection of students' sense of connection, belonging, and confidence within their academic community.

The experience of the Faculty of Business and Law further demonstrates the potential value of dedicated student-success structures such as the Centre for Student Success (CfSS). Since its establishment in 2022, the Faculty has experienced sustained improvements in continuation rates, reaching 95% in 2023–24, while also reducing attainment gaps and increasing student participation. Although multiple factors contribute to student outcomes, the comparative faculty data suggest that a coordinated and evidence-based approach to student support can play a significant role in enhancing progression and persistence.

At a time when higher education institutions face increasing pressures relating to student retention, wellbeing, and widening participation, the model presented in this paper offers a practical, scalable, and transferable framework for supporting diverse student populations. Future research should examine the long-term sustainability of such interventions, explore their impact across different institutional contexts, and further investigate the relationship between belonging, engagement, and student success. Ultimately, the findings highlight that when students feel seen, supported, and connected, they are more likely to engage, succeed, and fulfil their academic potential.

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FLORENCE PROJECT – DESIGNING FROM WITHIN: A LIVING LAB MODEL FOR INNOVATIVE HIGHER EDUCATION INSIDE A MEDICAL CENTER

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Abstract

The Florence Project is an academic living lab embedded inside Soroka Medical Center that relocates design education from the studio into everyday clinical life. Students spend an entire semester working in hospital wards, collaborating with staff, patients, and families while researching, mapping services, and testing solutions in real time. Rather than simulating reality, the program treats the hospital itself as a classroom and authentic constraints as learning drivers. This paper presents the Florence model as an innovative pedagogical framework for higher education and illustrates it through an in-depth case study focused on transforming the pediatric meal experience. Drawing on experiential learning, participatory design, and work-integrated learning literature, the paper argues that immersive, interdisciplinary collaboration cultivates empathy, systems thinking, and professional readiness while simultaneously producing measurable institutional impact.

Keywords: *Living lab, experiential learning, work-integrated learning, design education, interdisciplinary collaboration.*

1. Introduction

The Florence Project emerged from a growing gap between design education and the realities graduates encounter in complex public systems. While studios offer protected spaces for experimentation, they rarely expose students to organizational constraints, emotional intensity, and multi-stakeholder negotiations that define contemporary healthcare. In partnership with Bezalel Academy of Arts and Design Jerusalem and Soroka Medical Center, the program embeds students directly inside the hospital, transforming a functioning medical center into a site of learning, research, and innovation.

2. Theoretical background

In recent years, higher education has increasingly shifted from knowledge transmission toward competency-based and practice-oriented learning. Universities are expected not only to provide disciplinary knowledge but also to prepare graduates to operate effectively in complex, uncertain, and collaborative professional environments. This shift has generated growing interest in pedagogical models that integrate learning with authentic practice rather than isolating it within classroom settings.

Experiential learning theory provides an early foundation for this approach. Kolb (1984) argues that learning emerges through iterative cycles of concrete experience, reflection, conceptualization, and experimentation. Knowledge is therefore constructed through engagement with real situations rather than acquired solely through abstract instruction. In design education, such cycles are particularly important, as understanding develops through doing, testing, and adapting.

Building on this perspective, situated learning theory suggests that knowledge is inseparable from the contexts and communities in which it is practiced (Lave & Wenger, 1991). Learning occurs through legitimate participation in communities of practice, where novices gradually develop professional identities. From this standpoint, classrooms detached from real systems risk producing decontextualized knowledge that may not transfer easily to professional settings.

Parallel developments in participatory and co-design research further challenge expert-driven models of problem solving. Innovation in complex social systems emerges through collaboration with stakeholders rather than through external analysis alone (Sanders & Stappers, 2008; Björgvinsson et al.,

2019). Designers increasingly function as facilitators of collective processes rather than authors of isolated solutions.

More recently, living labs have gained attention as infrastructures for open and situated innovation. Living labs treat everyday environments as experimental sites where users, professionals, and researchers jointly explore problems and test solutions in context (Schuurman & Tõnurist, 2017; Leminen et al., 2021). While commonly discussed in urban and technological innovation, their implications for pedagogy are only beginning to be explored.

At the same time, scholarship on work-integrated learning demonstrates that extended, authentic placements cultivate employability skills such as communication, adaptability, ethical judgment, and systems thinking more effectively than classroom-based instruction alone (Jackson, 2015; McRae & Johnston, 2022). These competencies align closely with those required in healthcare and other public systems.

Taken together, these bodies of literature point toward a shared conclusion: learning is most powerful when it occurs within the systems it seeks to influence.

The Florence Project operationalizes this convergence of experiential learning, situated practice, participatory design, living labs, and work-integrated learning. By relocating the entire semester into a functioning hospital, it transforms the clinical environment into a pedagogical infrastructure and positions students as temporary members of a professional community of practice. In doing so, the project extends these theories by demonstrating how living labs can serve not only as innovation platforms but also as sustained educational frameworks.

3. The Florence living lab model

Students relocate to Be'er Sheva for a semester and work daily inside hospital wards. Activities include observation, interviews, journey mapping, ideation workshops, rapid prototyping, and in-situ testing. Courses are co-taught with clinicians and hospital staff, modeling interdisciplinary practice. Learning is structured around long-form challenges that move from research to implementation, enabling students to experience complete innovation cycles.

Table 1. Core Components of the Florence Living Lab Pedagogical Model.

Component	**Educational Function**
Immersive placement inside hospital	Situated learning and authentic exposure to real constraints
Interdisciplinary teaching team	Integration of clinical and design knowledge
Long-form semester projects	Depth, ownership, and end-to-end innovation cycles
Rapid prototyping in situ	Immediate feedback and experiential iteration
Stakeholder co-creation	Collaboration and collective problem solving
Structured reflection	Critical thinking and knowledge consolidation
Implementation in the ward	Tangible impact and professional accountability

4. Case study: Transforming the meal experience in a pediatric ward

One cohort addressed an unexpected yet critical issue in one of the pediatric wards: despite high satisfaction with medical care, families consistently described hospital meals as depressing and stressful. The hospital asked the team to improve the experience with one strict constraint—the food itself could not be changed. This reframed the problem from nutrition to service and experience design.

Students conducted immersive fieldwork by observing kitchen operations, following food carts, eating alongside children, and interviewing parents, nurses, and dietitians. They mapped the entire food journey and discovered that dissatisfaction stemmed not from taste but from contextual factors such as lack of choice, eating alone in bed, poor timing, and negative emotional associations with meal delivery.

Working with staff, the team developed small systemic interventions: an in-ward ordering station for the caregivers present with the child; redesigned delivery carts with distinctive uniforms and music to create a positive moment; foldable tables enabling families to eat together; and revised dinner logistics including a flexible food box and shared refrigerator access.

All solutions were prototyped and tested iteratively. After one year of implementation, the hospital reported an 80% increase in meal satisfaction in the pilot ward compared with the other pediatric wards.

For students, the project demonstrated that meaningful healthcare innovation can emerge from redesigning relationships, schedules, and environments rather than products alone.

5. Learning outcomes

The immersive context fostered systems thinking, empathy, interdisciplinary collaboration, and professional confidence. Students learned to negotiate constraints, communicate with diverse stakeholders, and translate insights into implementable solutions. These capabilities align closely with competencies identified in contemporary work-integrated learning research.

6. Institutional and societal impact

Beyond education, the hospital benefited from tangible improvements and a new culture of collaborative innovation. Small interventions accumulated into noticeable enhancements in patient and caregiver experience, while staff began viewing students as partners rather than external consultants.

7. Discussion: Living labs as a new paradigm for higher education

The Florence Project invites a broader question that extends beyond design education: what happens when the boundaries between university and society dissolve?

Over the past decade, higher education has faced increasing pressure to demonstrate relevance, impact, and employability. Traditional instructional models—lectures, studios, and simulated projects—have proven insufficient in preparing students for environments characterized by uncertainty, interdependence, and rapid change. These concerns are widely documented in contemporary higher-education scholarship (Saltmarsh & Hartley, 2019; Jackson, 2015).

Within this landscape, living labs have emerged internationally as an alternative model for situated innovation. Living labs position real environments as experimental sites where users, professionals, and researchers co-create solutions in everyday settings, integrating research, development, and implementation (Schuurman & Tõnurist, 2017; Leminen et al., 2021).

The Florence Project extends this concept explicitly into pedagogy. Instead of treating experiential learning as a supplementary internship or short-term practicum, Florence embeds students for an entire semester inside an operational hospital. This approach aligns with experiential learning theory, which emphasizes cycles of action and reflection as the basis for knowledge construction (Kolb, 1984), and with situated learning, which frames learning as participation in communities of practice (Lave & Wenger, 1991).

This shift carries several implications for higher education.

From Simulation to Authenticity. Many academic programs attempt to simulate real-world complexity through case studies or role-play. Florence replaces simulation with authentic participation. Students encounter ethical dilemmas, time pressure, and organizational resistance—conditions that foster professional judgment and responsibility.

From Individual Creativity to Collective Agency. Participatory and co-design research suggests that innovation in complex systems emerges through collaboration rather than isolated expertise (Björgvinsson et al., 2019). Working inside the hospital, students function as facilitators and mediators within networks of stakeholders rather than as individual authors.

From Knowledge Acquisition to Capability Building. Work-integrated learning research shows that competencies such as adaptability, communication, and systems literacy develop most effectively through authentic professional engagement (Jackson, 2015). Florence can be understood as an intensive form of work-integrated learning embedded within a public institution.

From University as Observer to University as Partner. Engaged-university models argue that higher education should actively contribute to societal systems rather than observe them from a distance (Saltmarsh & Hartley, 2019). In Florence, the hospital becomes a partner in knowledge production, and learning and public value creation occur simultaneously.

While embedded learning requires long-term partnerships and institutional coordination, the benefits suggest a broader paradigm shift. Living labs therefore represent not merely a teaching technique but a structural rethinking of higher education as embedded practice within society.

8. Conclusion

Designing from within demonstrates that immersive, context-based education can simultaneously deepen learning and generate measurable public value. The Florence Project offers a replicable approach for universities seeking innovative teaching models that prepare graduates to work responsibly within complex systems.

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PREVENTION OF POSTURAL DEFECTS IN CHILDREN AND ADOLESCENTS IN PUBLIC HEALTH CARE ON THE EXAMPLE OF SELECTED EUROPEAN COUNTRIES

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Abstract

Correct body posture is one of the determinants of health and fitness. It promotes the proper functioning of the musculoskeletal system and internal organs. It is also correlated with mental well-being. Attention to so-called postural hygiene, which consists of correct posture, i.e. the ergonomic positioning of the body in static positions (standing, sitting) and during movement (walking, running, bending over to lift weights and any other everyday activity), should be a habit formed from early youth and even childhood. It seems that the school environment can play a key role here. This is all the more important because it is school-age children who are most often diagnosed with poor posture. Meanwhile, according to research conducted by scientists from Spain, Malta, Poland, Turkey and Romania, there is still much to be done in this area. Primary school teachers are often not adequately prepared and do not provide optimal education on postural hygiene. Children are not taught, using methods adapted to their cognitive abilities, the knowledge and skills that could become the basis for lifelong habits of correct posture and physical activity. In each of the countries covered by the project, the national healthcare system includes an assessment of the posture of children and young people, but the solutions adopted are not producing the expected results. Postural defects are mainly diagnosed by a family doctor, but sometimes also by a school nurse. Unfortunately, although school is the best place to provide education on postural hygiene and exercises to prevent posture defects, none of the countries surveyed has a formal (or informal) channel for communicating information between health centres, schools and parents. There is no such thing as a team focused on the well-being of children in this area. Another disadvantage is that no standardised posture assessment form has yet been developed that is clear and understandable to parents and children. The research yielded a set of recommendations to increase public awareness of the importance of correct posture for health and psychophysical well-being, with the most significant being promoting closer cooperation among families, healthcare providers, and schools. One way to improve postural hygiene among school children is to train teachers to recognize postural defects, share knowledge about the importance of proper posture for health, and conduct in-class exercises to prevent postural defects and promote physical activity. One such project is "Spine-Friendly Teacher, Spine-Friendly School" (2025-1-PL01-KA220-SCH-000350791).

Keywords: *Children's health, body posture, faulty body posture prevention, posture hygiene, health care.*

1. Introduction

The assessment of the ability to maintain correct posture should be an integral part of clinical examination, especially among children and adolescents, who are particularly vulnerable to the development of posture defects due to the plasticity of the musculoskeletal system (Griegel-Morris et al., 1992). Postural defects are a common phenomenon – in Poland, their prevalence is estimated at 50–70% of the population in their developmental years (Górecki et al., 2009). Similar observations have been reported in other European countries (Jorgić et al., 2023). This phenomenon is associated, among other things, with a decrease in physical activity and prolonged sitting (Salsali et al., 2023). The literature also emphasises the link between spinal deformities and depression, especially in adolescent girls (Dehcheshmeh et al., 2024). The implementation of screening tests may therefore be important not only for physical health, but also for supporting mental well-being.

2. Design

The project was proposed by researchers from Poland, who sent invitations to researchers from 14 European countries whose work on body posture in children and adolescents from the last 5 years was found in the Scopus, PubMed or Web of Science databases. Seven of the invited researchers responded to the invitation, but researchers from Finland, Germany and the United Kingdom withdrew due to a lack of consent from their university authorities or a lack of external funding. Researchers from Malta, Romania, Spain and Turkey joined the project and, together with researchers from Poland, agreed on the detailed research objectives and procedures. All authors are professionals actively involved in conducting research on posture prevention and improving physical fitness and psychophysical functioning in children and adolescents. Approval was obtained from the Ethics Committee in the country of the first author. The data was collected in a specially designed template in Microsoft Excel.

3. Objectives

The aim of the research was to compare legal regulations and measures taken within institutionalised healthcare aimed at the prevention and early diagnosis of posture defects in children and adolescents in selected European countries, to compile a list of good practices and to prepare recommendations that could increase the effectiveness of current posture care programmes for children and adolescents.

4. Methods

The project was carried out in several stages, which aimed to: (1) analyse the prevalence of postural abnormalities in children and adolescents in the countries covered by the project on the basis of publications from recent years; (2) collect information on legal regulations concerning guaranteed services in the field of postural screening in children and adolescents; (3) estimating the waiting time for therapy in a public health centre for a child diagnosed with a posture defect; (4) summarising the information collected – strengths and weaknesses of the measures implemented in individual countries; (5) developing recommendations for good practices related to the prevention of posture defects.

5. Results

5.1. Prevalence of postural abnormalities in children and adolescents

Research by Sacco and Catania (2019), one of the few studies conducted on the Maltese population, showed that scoliosis occurs in 5.3% of 13- to 15-year-olds, with girls being 2.25 times more likely to be affected.

Research conducted on a population of 2,680 Polish children (aged 6–18) showed lateral banding of the spine in 14.6–25.7% of the participants, depending on the assessment method (Maciałczyk-Paprocka et al., 2018). In the 11-13 age group, scoliosis was found in 51.94% of theparticipants (Wilczyński et al., 2020). Assessment of trunk stability showed that changing from a standing to a sitting position leads to significant changes in spinal curvature (Drzał-Grabie et al., 2015). Lower limb defects are strongly correlated with body weight (Brzeziński et al., 2019), and hindfoot valgus in younger children is observed in the vast majority of them (Jankowicz-Szymańska & Mikołajczyk, 2016).

Studies conducted in Spain have shown an increase in the frequency of hiperkyphosis with age (Sainz de Baranda et al., 2020a). In a sitting position, hiperkyphosis was found in more than half of the students (Sainz de Baranda et al., 2020b). Physical exercise has a beneficial effect on the alignment of body segments (Molina-Garcia et al., 2020), and in children between the ages of 5 and 11, there is an improvement in foot alignment (confirmed by the FPI-6 test) (Martínez-Nova et al., 2018).

Researchers from Romania have determined that the most common posture defects in children are forward head posture, and hiperkyphosis (Vlad et al., 2025). Lifestyle and incorrect sitting habits are significant risk factors for the development of posture defects (Dop et al., 2024). In 11-16-year-olds, the most commonly diagnosed conditions are hiperlordosis and hiperkyphosis, as well as lateral banding of the spine (Serseniuc et al., 2025). Education and physiotherapy bring about a significant improvement in spinal alignment (Cristuţă, 2016).

In Turkish children, the incidence of scoliosis is, depending on the study, 25/1000 (Ugras et al., 2010), 23/1000 (Yılmaz et al., 2020) or 12/1000 (Sağlam et al., 2024) cases. Poor posture and low physical activity are associated with back pain (Ozdemir et al., 2021). A corrective exercise programme improves posture and can also be carried out in pre-school children (Kayapinar et al., 2012).

5.2. Legal regulations and benefits guaranteed by the public healthcare system

In each of the project countries, the Ministry of Health or other relevant authority introduces provisions regulating the scope of guaranteed health care services, including posture health care for children and adolescents. The regulations cover periodic health examinations, which are carried out at designated points in a child's development from birth to the age of 18. In each country, these check-ups also include an assessment of body posture, with particular attention paid to the presence of scoliosis. The assessment is carried out by a family doctor or paediatrician (in Poland, the examination is also carried out by a school nurse). In none of the countries do the regulations introduce a standardised form of posture assessment protocol, nor do they oblige health centres to equip the doctor conducting the posture assessment with measuring equipment (often the doctor does not even have a scoliometer and the assessment is based solely on visual assessment) nor is there an established path for cooperation with the school environment, which should be involved with the doctor and parents in the process of prevention and treatment of children's posture defects. In some countries, e.g. Poland, the diagnosis of a posture defect by a doctor does not automatically result in the child being referred for rehabilitation. Such a referral must be issued by an orthopaedic or a rehabilitation doctor.

5.3. Waiting time for treatment

The time needed to start rehabilitation varies from country to country.

In Poland, it takes an average of 201 working days from the diagnosis of a posture defect to the start of rehabilitation. This time is similar in large, medium and small cities (calculated on the basis of data from 124 health centres randomly selected from each province in Poland https://swiatprzychodni.pl/specjalnosci/rehabilitacja/).

In Romania and Spain, the waiting time for posture defect therapy depends on the region of residence. In Romania, children usually do not wait longer than two weeks to start therapy under the public health service (according to therapists and parents). In Spain, the average waiting time for therapy in 2024 was 94 days (https://www,epdata,es/datos/listas-espera-sanidad-publica/24/espana/106?utm_source=chatgpt.com).

The waiting time for rehabilitation in public health facilities in Turkey is usually between 3 and 6 months and also depends on the region. In larger cities, this time is usually shorter (https://www,saglik,gov,tr/TR-107086/saglik-istatistikleri-yilligi-2023-yayinlanmistir).

No confirmed data is available on waiting times for posture defect therapy for children and adolescents in Malta.

6. Discussion

The current paediatric care system is not delivering the expected results. Postural defects in children are still diagnosed in a large number of cases, and the methods of prevention and care are not precisely defined. The high incidence of postural defects in all the countries analysed indicates a need to supplement systemic preventive measures. Despite the existence of screening tests, the lack of standardised assessment protocols and formal channels of cooperation between doctors, physiotherapists and schools limits the effectiveness of interventions. An additional argument for intensifying preventive measures is the documented link between spinal deformities and depression (Dehcheshmeh et al., 2024). In none of the countries covered by the project is the physiotherapist, the person best trained in the

process of education to diagnose posture defects, involved in systemic solutions for postural care for children and young people.

It would be helpful to create a clear examination protocol form focused on specific tests and methods of assessing posture in order to streamline the examination, make the results understandable to parents, and focus the examination on specific, most common and most harmful skeletal deformities in children. The creation of a simple protocol would be a gesture towards parents. Posture assessment results recorded in a simple and legible manner would improve communication between doctors and parents and increase parents' awareness and involvement in shaping healthy behaviours in children.

Attention should also be paid to the equipment in the doctor's office and the school nurse's office. Enriching it with simple tools such as a scoliometer, measuring tape, rear foot valgus-varus gauge and posturographic grid would have a positive impact on the accuracy and reliability of the examination.

7. Conclusions

1.There is no significant difference in the incidence of posture defects in children and adolescents in the countries covered by the observation. The incidence and type of defects were very similar in Poland, Turkey, Spain, Romania and Malta.

2. Systemic care for children and adolescents regarding the diagnosis and prevention of posture defects in Poland and selected European countries differs slightly.

3. The waiting time for posture defect therapy depends on the region of residence. In Poland and Turkey, the waiting time in public health facilities is up to several months, while in Romania it is no more than two weeks. Partners reported that parents often opt for private visits.

4. Analysing the example of Spain, it seems that the best way to promote so-called postural hygiene is to implement preventive and educational programmes in schools, both in theoretical and practical form.

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ENHANCING STUDENT ENGAGEMENT THROUGH MOVEMENT AND PROACTIVITY: A COMPARATIVE CLASSROOM STUDY USING AN ISO 26000 GAME*

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Abstract

This research paper examines how classroom movement influences student engagement during the introduction of the ISO 26000 standard. Using theories of active learning and embodied cognition, this study compares a specific teaching session delivered to two distinct master's-level classes at a business school, both exposed to identical learning objectives and content, but via different pedagogical modalities. In the first instructional setting, students were seated around a single table and introduced to the key principles of ISO 26000 through a card-based game. Each student drew a card that presented one element of the standard. Although the activity incorporated an element of gamification, students remained physically static throughout the session. Observational data revealed a rapid decline in attention, motivation, and curiosity, suggesting limited cognitive engagement. In the second setting, a world café methodology was used. Multiple tables were organized, each corresponding to one of the major themes of ISO 26000. Students rotated among the tables, engaging in brief collaborative discussions at each station. In this configuration, physical movement was an integral component of the learning process. Students demonstrated higher levels of participation, curiosity, and proactivity, as well as sustained attention over time. The contrast between the two experiences highlights the pedagogical value of movement as a catalyst for engagement and learning. These findings are consistent with research on active learning (Prince, 2004; Freeman et al., 2014; Park & Xu, 2024), embodied cognition (Sullivan, 2018; Zou et al., 2025), and the role of movement in enhancing cognitive processes and motivation (Garret, 2022; Oliveras-Ortiz et al., 2020). This presentation argues that integrating purposeful movement into instructional design can significantly enhance student engagement. It invites educators to reconsider classroom spatial organization and learner posture as central variables in the learning process. It proposes movement as a powerful lever for fostering proactivity and meaningful learning.

Keywords: *Active learning, student engagement, classroom movement, pedagogical innovation.*

1. Introduction

Active learning has become a central approach in higher education, particularly in disciplines requiring critical thinking and applied reasoning (Prince, 2004; Freeman et al., 2014; Park & Xu, 2024). It is usually defined as instructional approaches that engage students in meaningful activities rather than passive listening (Konopka et al., 2015; Hendrickson, 2021) and has been summarised as "*a student-centered approach to the construction of knowledge focused on activities and strategies that foster higher-order thinking*" (Doolittle et al., 2023). In fact, activity alone does not guarantee learning (Chi & Wylie, 2014). What matters is not simply participation; as Fredricks et al. (2004) underline, cognitive and emotional engagement require explanation, integration, and reflection.

This issue is particularly relevant in CSR strategy education (Schimperna et al., 2022). Teaching ISO 26000 requires students to understand the interconnected domains of social responsibility and stakeholder expectations (ISO, 2010). Sustainability education research highlights the importance of systems thinking and integrative reasoning in this context (Christou et al, 2024; Peretz, 2025). Although experiential and game-based approaches are widely used in CSR education (Waddock & Lozano, 2013; Park & Xu, 2024), their effectiveness depends on careful design and alignment (Romero & Kalmpourtzis, 2020; Silverthorn, 2020), and engagement may decline when activities are insufficiently structured (Mickael, 2006; Emblen-Perry, 2018).

*Use ChatGPT to summarize certain parts of the text and reorganize it. Use DeepL for translation. Use Grammarly to check linguistic quality and bibliography.

Recent work on embodied cognition suggests that movement and spatial organization can influence attention and conceptual integration (Garret, 2022; Oliveras-Ortiz et al., 2020). So, raises a practical question: "*How do spatial configuration and structured rotation shape engagement within active learning formats?*" To address this question, the present study compares two classroom implementations of the same ISO 26000-based CSR game that differ primarily in movement and spatial organization, to identify design principles for CSR strategy education.

2. Literature review

Active learning has become a central approach in higher education, especially in disciplines that require critical thinking and applied reasoning (Prince, 2004; Freeman et al., 2014; Park & Xu, 2024). It is generally defined as instructional approaches that engage students in meaningful activities rather than passive listening (Bonwell & Eison, 1991; Konopka et al., 2015; Hendrickson, 2021; Sullivan, 2018; Zou et al., 2025). Doolittle et al. (2023), after reviewing 161 definitions, describe it as "a student-centered approach to the construction of knowledge focused on activities and strategies that foster higher-order thinking."

Research distinguishes among behavioral, cognitive, and emotional engagement (Fredricks et al., 2004). Behavioral engagement refers to visible participation, whereas cognitive engagement reflects students' "investment in learning." Only forms of engagement that promote explanation, connection, and integration lead to durable understanding (Chi & Wylie, 2014). Emotional engagement captures the affective dimension of learning, reflecting students' sense of interest, value, and personal relevance, which in turn shapes their willingness to invest cognitively and sustain effort over time. Finally, what matters is not simply that students are active, but that they are constructively engaged.

This distinction is particularly relevant in CSR strategy education. Teaching ISO 26000 does not consist of presenting a list of principles to memorize. The framework addresses interconnected domains -governance, human rights, labor practices, environment, and others (ISO, 2010)- that must be understood in relation to one another. Students need to reason across themes, consider trade-offs, and integrate multiple stakeholder perspectives. Sustainability education research emphasizes the importance of systems thinking and stakeholder integration in this context (Christou et al, 2024; Peretz, 2025). For this reason, experiential and interactive approaches such as simulations and games are frequently used in CSR and management education (Waddock & Lozano, 2013; Claro & Esteves, 2021; Kozlovskaya, 2021), and some studies suggest they can even transform students' mindsets (Żmuda et al., 2015; Bindumenon, 2024).

At the same time, interactive formats are not automatically effective. Engagement may decline when activities become repetitive or insufficiently structured (Michael, 2006; Emblen-Perry, 2018). Meta-analyses show that active learning improves performance when it incorporates explanation, retrieval, and discussion (Freeman et al., 2014), but its effectiveness depends on careful design, alignment with assessment, and contextual conditions (Romero & Kalmpourtzis, 2020; Silverthorn, 2020).

Recent work on embodied cognition further suggests that learning is partly grounded in sensory and motor processes (Garret, 2022). Movement and spatial organization can influence attention, memory, and conceptual integration (Medina, 2014; Oliveras-Ortiz et al., 2020; Sullivan, 2018; Zou et al., 2025). Pedagogical formats that include rotation or spatial segmentation may therefore support deeper engagement by helping students structure and connect ideas. In the case of ISO 26000, a rotational format can reflect the framework's systemic architecture, encouraging what Chi and Wylie (2014) describe as "constructive" engagement rather than mere activity.

3. Empirical study

This study adopts a comparative pedagogical case design to examine how different configurations of active learning influence student engagement in CSR strategy education. Rather than comparing active learning to lecturing, it contrasts two implementations of the same ISO 26000-based CSR game, focusing on how spatial organization and movement affect engagement.

Both two-hour sessions were conducted in the same Business School course, at the same academic level, with identical learning objectives and the same instructor. ISO 26000 was presented as a strategic framework addressing interconnected domains of social responsibility, to foster integrative reasoning across themes.

In Group 1, 28 students worked at fixed tables with CSR cards, analyzing and categorizing them within two stable teams. Although initially engaged, concentration and discussion intensity declined after about 30 minutes. In group 2 (30 students), the same materials were distributed across themed stations, and five teams of students rotated among the tables at regular 10-minute intervals. This format introduced movement and repeated transitions, and engagement remained high throughout the session.

The analysis used a comparative interpretive approach, contrasting observational data across three dimensions: behavioral, cognitive, and emotional engagement, with particular attention to the role of spatial configuration and movement in sustaining engagement.

The comparison of the two ISO 26000 game formats shows that active learning does not automatically produce sustained engagement. In both groups, students were initially behaviourally engaged, but important differences emerged over time. In the static table-based format, concentration and discussion intensity declined after approximately thirty minutes, and interactions became more procedural than exploratory. In contrast, the rotational station-based format maintained high levels of participation throughout the session. The structured transitions and physical movement appeared to reactivate attention and renew energy. More importantly, differences were visible at the cognitive level. In the static format, discussions focused mainly on categorizing content within ISO 26000 domains. In the rotating format, students increasingly made connections between topics and recognized interdependencies among subject areas. For example, they realized that they were not always able to distinguish between core subjects and that they overlapped. The spatial segmentation of topics encouraged comparisons and changes in perspective. Emotional engagement also remained higher in the rotational group, with students expressing greater enthusiasm and willingness to continue. Overall, the findings suggest that while both formats were "active," only the rotational design sustained behavioural, cognitive, and emotional engagement simultaneously. The results, therefore, support the argument that micro-level design features -particularly movement, spatial organization, and structured variation- play a crucial role in fostering constructive engagement in CSR strategy education.

4. Discussion

The findings of this study suggest that, for Business School instructors, the effectiveness of active learning depends not simply on the use of interactive tools but also on how those tools are structured. Although both groups engaged in the same ISO 26000 game, only the rotational format sustained behavioural, cognitive, and emotional engagement, reinforcing the idea that activity alone does not guarantee meaningful learning (Chi & Wylie, 2014). In the static format, discussions gradually became procedural, whereas the rotational format-maintained intensity through structured transitions and movement. This corroborates research showing that active learning is more effective when it promotes explanation and reflection rather than superficial participation (Freeman et al., 2014). For instructors, introducing pedagogical rhythm and variation can help prevent attentional decline (Bligh, 2000). Physical movement -such as rotating between tables- may serve as a practical cognitive reset, consistent with insights from embodied cognition research (Barsalou, 2008; Glenberg, 2010).

Moreover, spatially organizing content into thematic stations can make the interconnected structure of frameworks such as ISO 26000 more visible. Sustainability education scholars emphasize that CSR learning requires systems thinking and stakeholder integration (Sterling, 2004; Wiek et al., 2011). Rotational formats can operationalize these objectives by encouraging comparison across domains and perspective shifts. In this sense, classroom design becomes part of constructive alignment (Biggs & Tang, 2011), ensuring coherence between learning objectives and pedagogical form. For Business School instructors teaching complex, multidimensional subjects, spatial configuration and movement should therefore be considered deliberate pedagogical strategies rather than logistical details. Small structural adjustments in classroom organization can significantly influence the depth of engagement with strategic sustainability concepts.

5. Conclusion & limitations

Research on embodied cognition further suggests that spatially distributed and movement-based formats can enhance attention and memory (Barsalou, 2008; Glenberg, 2010). This is particularly relevant in sustainability and CSR education, which require systems thinking and stakeholder integration (Sterling, 2004; Wiek et al., 2011). Nevertheless, little research examines how micro-level design choices -such as spatial configuration or structured rotation- shape engagement within active learning formats. To address this gap, the present study compared two ISO 26000-based game designs that differed in movement and spatial organization to derive pedagogical principles for CSR strategy education.

Constructive alignment theory posits that learning activities should be coherently aligned with intended learning outcomes and assessment methods (Biggs & Tang, 2011). Extending this logic, pedagogical form should also reflect the discipline's epistemological structure. CSR strategy is normative, relational, and systemic. It requires perspective-taking, integration of stakeholder claims, and evaluation of trade-offs. When learning environments mirror the systemic nature of CSR -through thematic segmentation, circulation, and comparison- they may facilitate deeper integration. Rotational pedagogies can simulate

stakeholder plurality by exposing students to multiple thematic centers, encouraging perspective shifts and relational reasoning (Wiek et al., 2011). The question, therefore, is not whether active learning should be used in CSR education, but how it should be structured to reflect the field's inherent complexity and pluralism.

This study is based on personal observations of two approaches to teaching CSR in a Business School classroom. As such, its conclusions remain exploratory. The comparison was conducted within a single course context and relied primarily on observational evidence rather than systematic measurement. To strengthen the validity of these findings, future research should test the impact of rotational versus fixed teaching formats in a more formal and controlled manner. This could include implementation across different types of classes, academic levels, and institutional settings. The use of structured questionnaires or validated engagement scales would also allow for a more precise assessment of behavioral, cognitive, and emotional engagement. Such empirical validation would help determine whether the observed benefits of the rotational format are generalizable beyond this specific teaching context.

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ALISIO - A STEAM EDUCATIONAL PROJECT BRINGING EARTH OBSERVATION TO CANARY ISLANDS CLASSROOMS

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Abstract

In December 2023, the Canary Islands launched their first satellite, ALISIO-1, into space. Since then, it has served as a testbed for innovative technologies to monitor both the short- and long-term effects of climate change in the region. Inspired by this mission, the ALISIO Educational Project was created to introduce secondary school students across the Canary Islands to the analysis of satellite imagery and its relevance in understanding and addressing real-world environmental challenges. Designed as a comprehensive STEAM initiative, the project integrates multiple areas of knowledge (science, technology, engineering, arts and mathematics) while promoting the simultaneous development of scientific thinking, eco-social awareness, and critical reasoning. This paper presents the design and preliminary outcomes of the first implementation of the ALISIO Educational Project, which aims to impact on students' scientific competence, awareness of climate and environmental issues, and motivation toward STEAM disciplines.

Keywords: *STEAM education, project-based learning, secondary school, teacher training, sustainable development.*

1. Introduction

Contemporary society operates in a highly technological environment that requires not only the acquisition of scientific knowledge but also the development of analytical, creative, and problem-solving competencies that enable individuals to address complex issues with social and environmental implications (García et al., 2017). In this context, STEAM (Science, Technology, Engineering, Arts and Mathematics) educational approaches have gained increasing relevance by promoting active, interdisciplinary methodologies focused on solving real-world problems (Oliveros-Ruiz, 2019; García-Bullé, 2021). Among the methodologies that facilitate the implementation of this interdisciplinary approach, Project-Based Learning (PBL) stands out. This methodology enables students to address real-world problems through processes of inquiry, experimentation, and scientific communication (Domènech-Casal, 2019; Santillán-Aguirre et al., 2020).

In this regard, the educational use of emerging technologies opens new possibilities for the development of innovative STEAM learning experiences. One particularly promising approach is the use of Earth observation images obtained through optical instruments installed on orbiting satellites. These resources allow students to analyse environmental and territorial phenomena from a data-driven scientific perspective, supporting the development of both digital and scientific competencies. In particular, scientific instruments such as the DRAGO space camera developed by IACTEC-Espacio (Oscoz, 2021) represent examples of advanced technology that can be incorporated as educational resources to bring students closer to scientific research and the analysis of global environmental challenges.

Furthermore, contemporary science education cannot be separated from the environmental challenges facing society. Education for Sustainable Development (ESD) promotes the formation of a critical and responsible citizenship capable of making informed decisions and actively participating in the search for solutions to environmental problems (Sterling, 2001; Wals, 2014). Integrating real environmental issues into educational processes encourages students to develop the knowledge, attitudes, and values necessary to support environmental conservation and the development of more sustainable societies (Vilches & Gil, 2012).

Within this context, the present study describes the design and implementation of a STEAM educational activity aimed at secondary school students that uses satellite Earth observation imagery as a teaching resource to develop research projects related to the Sustainable Development Goals. Through a

project-based methodology, students analyse environmental phenomena using spatial data and develop scientific communication outputs, thereby fostering critical thinking, ecosocial awareness, and the development of STEAM competencies within an interdisciplinary learning environment.

2. Objectives

The main objectives of the ALISIO Educational Project are:

1. To promote interdisciplinary STEAM learning by integrating science, technology, engineering, arts, and mathematics within a multidisciplinary framework connected to real-world challenges.
2. To develop students' scientific inquiry and critical thinking skills through the application of the scientific method in the analysis and interpretation of satellite imagery and environmental data.
3. To raise awareness of climate change and environmental sustainability, encouraging students to examine local and global environmental issues affecting the Canary Islands.
4. To support teacher training in Earth Observation and Copernicus data, enabling educators to incorporate satellite-based research activities into their classroom practice.
5. To foster students' scientific communication and collaboration skills through the preparation and presentation of research results in a student conference format, including scientific posters and oral presentations.

3. Methods

The ALISIO Educational Project follows a STEAM educational approach, supported by inquiry-based learning and Project-Based Learning (PBL) methodologies, in which teachers and students participate in training experiences and research-oriented activities. To evaluate the impact of the program, a mixed-methods assessment strategy was applied, combining quantitative and qualitative approaches to analyse both teacher professional development and student learning outcomes.

The ALISIO Educational Project was implemented through a teacher training phase followed by a classroom research phase carried out with secondary school students across the Canary Islands. A total of 9 secondary education centres and 29 teachers from schools located on different islands of the archipelago (Tenerife, Gran Canaria, La Palma, and Fuerteventura) participated in the program. Due to this geographical dispersion, the training sessions were conducted online to ensure accessibility and participation from all islands.

The project is implemented through three sequential phases. In the first phase, secondary school teachers receive specific training on the use of Earth observation data and on the educational implementation of the proposed activity. In the second phase, these trained teachers implement the project in their own secondary school classrooms, guiding students through research activities based on the analysis of satellite images. Finally, in the third phase, a student conference is organised, where participating students present the results of their investigations in the form of scientific posters or oral presentations, following formats commonly used in academic conferences. The following subsections describe each phase of the project in greater detail.

3.1. Phase 1 - Secondary school teacher training

The first phase of this educational project focuses on teacher training, which serves as the foundation for subsequent classroom implementation. This phase consists of four synchronous online sessions, each lasting two hours, delivered via videoconference. The sessions are designed to provide both a strong pedagogical framework and practical skills in the context of Earth Observation and satellite data analysis. In addition, teachers have access to a Moodle platform containing supplementary resources to support self-directed learning. At the start of the training, participants complete structured questionnaires with both open- and closed-ended questions designed to elicit their prior knowledge, expectations, and motivation regarding the integration of STEAM and space science into their teaching practice. This assessment allows for a tailored approach, ensuring that the professional development responds to teachers' needs, builds confidence, and fosters reflective engagement with the content. The following subsections describe the contents of each section of this first phase of the project.

3.1.1. Session 1 – Introduction and pedagogical framework. The first session began with a welcome and included an initial questionnaire designed to assess participants' motivations and prior knowledge. This session introduced the educational framework of the project, highlighting its alignment with secondary education and its connection to the United Nations Sustainable Development Goals (SDGs). The main objectives of the initiative were also discussed. Teachers were introduced to the expected project deliverables, particularly the preparation of a scientific poster. This included an overview of its structure,

components, and communicative purpose. The session concluded with a discussion on how the project could be implemented in secondary school classrooms.

3.1.2. Session 2 – Scientific context and introduction to Earth observation. The second session began with an introduction to the Instituto de Astrofísica de Canarias (IAC) and the IACTEC-Space division research group. Participants learned about some of their key scientific and technological projects to provide context and motivation for the day's activities. This was followed by a brief explanation of the electromagnetic spectrum. The session included a practical activity titled "Observing the Earth from Low Earth Orbit," which demonstrated how satellite imagery is obtained and utilized. At the end of the session, teachers created their user accounts in Copernicus Browser (Kovács, 2026), the platform used for accessing and analyzing satellite data.

3.1.3. Session 3 – Tools and data exploration. The third session emphasized the practical applications of the Copernicus Browser, particularly in the context of STEAM-based learning for students. Participants were introduced to the platform's key functionalities and interactive tools, showcasing how satellite imagery can be effectively utilized for educational purposes. For instance, students can use the Copernicus Browser to analyze land use changes over time, fostering discussions about environmental science and geography. They can visualize deforestation impacts by comparing historical and current satellite images, prompting inquiry-based learning. Another example involves investigating urban heat islands by examining temperature differences in various city areas through thermal satellite data. This application not only engages students in real-world data analysis but also integrates principles from science and math. Overall, the session provided teachers with practical strategies to incorporate the Copernicus Browser into their curriculum, enhancing students' understanding of environmental observation while developing critical skills in analysis, interpretation, and problem-solving across multiple disciplines.

3.1.4. Session 4 – Questions, review, and consolidation. The final session focused on addressing questions and resolving technical difficulties. It included a review of the main tools presented during the training and introduced additional web-based resources related to Earth Observation and environmental analysis. At the end of the training program, teachers completed a final questionnaire to evaluate their experience.

3.2. Phase 2 - Implementation of the project in participating schools

In the second stage of the project, teachers implement the initiative in secondary classrooms, guiding students through inquiry-based project using satellite data. Students work collaboratively, applying the scientific method to investigate environmental phenomena and communicate their findings through scientific posters. The posters are expected to describe the context of the studied issues or phenomena, the mathematical tools that were used, the reference satellite imagery, a representation of the obtained data and the conclusions of the research, linking them with the SDGs and proposing solutions when applicable.

To support learning and reflection, an accessible evaluation rubric is provided to both teachers and students, enabling self-assessment and formative feedback. At the outset, students complete questionnaires on motivation, expectations, and prior knowledge, while end-of-project surveys capture their satisfaction and perceived learning outcomes.

3.3. Phase 3 - Student conference held at the IACTEC headquarters

At the institutional level, each participating school selects its best research project and poster, which then advances to a semifinal evaluation by an academic panel. The top project from this stage is invited to deliver an oral presentation at the final student conference, held in person, while the semifinalist teams present their scientific posters. To support formative assessment and skill development, teachers use an observation rubric to evaluate students' performance, including the development of linguistic competence and their ability to defend scientific work effectively before their peers.

Additionally, a brief peer-assessment questionnaire is administered, in which teams evaluate the finalist projects presented by other schools, providing constructive feedback by highlighting strengths and suggesting proactive improvements. This structure replicates the dynamics of a real scientific conference, enabling students to communicate research, receive feedback, and engage critically with the work of peers across the Canary Islands, reinforcing both scientific reasoning and collaborative learning.

4. Discussion

At the time of writing the present document, the ALISIO Educational Project is overgoing phase 2 ("Implementation of the project in participating schools"). Preliminary feedback points to a significant

positive impact on both teachers and secondary and upper-secondary students. For teachers, participation has provided specialized training in space technologies and their applications, enhancing their understanding of Earth observation, the electromagnetic spectrum, and space missions. This knowledge broadens their pedagogical repertoire, equipping them with tools to present complex scientific content in accessible and engaging ways. The use of digital platforms such as the Copernicus Browser serves as a powerful didactic resource, enabling teachers to integrate real-world data into inquiry-based learning activities.

Questionnaire responses collected before the training phase revealed that teachers were particularly interested in learning new methodologies, techniques, and resources to complement and expand their knowledge. Some expressed a desire to convey to students the joy of conducting scientific investigations connected to their local environment, while others sought practical strategies to use satellite observation data to foster critical and scientific thinking. After the training, teachers reported significant changes in their perception of satellite imagery as a classroom resource. One commented that the experience "opened a window to learn how to use a tool I had never tried before, which offers many learning possibilities," while a visual arts teacher noted that it "completely changed my perspective, because until now, in Photography classes, we primarily work with artistic photography."

For students, collaborative engagement in research projects fosters rigorous data collection and analysis using satellite imagery, alongside cross-referencing with other sources. This approach strengthens digital literacy and evidence-based reasoning, core components of scientific thinking. Working in teams also develops communication and collaboration skills, as students negotiate ideas with peers of diverse abilities and perspectives. Presenting their results—first to classmates and then to an external panel—enhances oral and written communication, argumentation, and the ability to defend conclusions. Moreover, analyzing environmental changes in selected areas with respect to the United Nations Sustainable Development Goals (SDGs) helps students connect global objectives to local, real-world problems, reinforcing understanding of global challenges and motivating practical, sustainable solutions.

The anticipated strengths of the project include the integration of STEAM and sustainability education, promotion of inquiry-based and project-based learning methodologies, and the creation of authentic scientific experiences through conferences, poster presentations, and peer-assessment activities. While challenges such as motivating teachers to adopt innovative approaches, ensuring equitable access to quality digital resources, and managing the logistical demands of student and teacher participation in the in-person conference remain, the combination of hands-on training, collaborative research, and structured evaluation is expected to yield meaningful pedagogical transformation. Teachers gain confidence in applying space-based technologies in the classroom, while students develop scientific curiosity, critical thinking, eco-social awareness, and competencies that extend beyond traditional disciplinary boundaries.

5. Conclusions

Based on its comprehensive methodology, the ALISIO Educational Project is expected to have a substantial impact on both teachers and secondary and upper-secondary students. The innovative integration of STEAM education with sustainability, coupled with a structured sequence of teacher training, student research, and presentation phases, provides a framework likely to foster scientific curiosity, critical thinking, and evidence-based reasoning among students.

Teachers are expected to benefit from specialized training in space technologies and the use of advanced educational tools such as Copernicus Browser, thereby enhancing their pedagogical repertoire and confidence in implementing inquiry-based and project-based learning strategies in the classroom. Similarly, students are expected to develop key competencies, including digital literacy, teamwork, scientific communication, and the ability to analyze real-world environmental phenomena through satellite imagery, connecting local observations with global sustainability challenges.

The inclusion of structured evaluation tools—such as self-assessment rubrics, peer-assessment questionnaires, and observation rubrics for oral presentations—supports reflection, feedback, and skill development, ensuring that both teachers and students engage meaningfully with the project. The design also anticipates the creation of authentic scientific experiences through conferences and collaborative activities, promoting cross-institutional interaction and the exchange of ideas.

Overall, the ALISIO Educational Project is expected to offer a transformative educational experience, providing a well-grounded and innovative framework for fostering scientific literacy, eco-social awareness, and the development of competencies essential for students to engage proactively with the challenges of the 21st century.

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FAMILY COMPREHENSIVE SEXUALITY EDUCATION EXPERIENCES AND OPINIONS FROM ADOLESCENTS AND THEIR PARENTS

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Abstract

Comprehensive Sexuality Education (CSE) is defined as a lifelong learning process that begins in childhood and is ideally based on shared educational responsibility, primarily between schools and families. In Italy, there is no law formally introducing CSE in schools as a multidisciplinary and transversal subject, in line with international documents and guidelines. Moreover, in sociocultural and political debates, many Italians advocate for parents' primary educational role, citing Article 30 of the Italian Constitution, which establishes both the duty and the right of families to educate their children. However, sexual and relational issues are often neglected by parents due to a lack of knowledge, feelings of discomfort and embarrassment, or facing personal, cultural, and social factors. At the same time, adolescents consider CSE crucial and necessary, and affirm accessing information from multiple sources, such as the web and peers. Hence, literature often reports family communication as inadequate or unsatisfactory. The present research aims to explore CSE's experiences and opinions, as well as family communication experiences, in a triadic perspective, involving Italian adolescents and their parents. The research consists of two phases: 1) a qualitative phase including semi-structured interviews with families, specifically an adolescent, the mother, and the father in each family; and 2) a quantitative phase involving the administration of an online questionnaire to adolescents, mothers, and fathers. The first phase was an exploratory study involving 50 families. The second phase is also characterized as an exploratory study that aims to reach a wider, more heterogeneous sample, enabling the conduct of statistical analysis and comparisons of experiences, opinions, and communication styles between families and Italian contexts. Overall, the present research aims to provide a deeper understanding of how families discuss sexuality and relationship issues, and how adolescents and parents position themselves on CSE topics, with the future goal of designing training and educational programs for both adolescents and parents.

Keywords: *Comprehensive sexuality education, family communication, adolescents, interviews, questionnaires.*

1. Introduction

Comprehensive Sexuality Education (CSE) is recognized as a human right and as a lifelong learning process since early childhood (IPPF, 2017; UNESCO, 2018; WAS, 2014), supporting healthy development and behavior, increasing knowledge and awareness, and preventing abuse (Bruno, 2024; Putri, 2022; WHO, 2010). CSE should be addressed in the school environment, where teachers and educators share educational responsibility with families (IPPF, 2018; UNESCO, 2023), to foster open and safe contexts to discuss with honesty, trust, and comfort, and to increase positive and respectful attitudes toward one's own and others' sexuality (Ball et al., 2023; Benoit & Ronis, 2023; Castro et al., 2024; Nattabi et al., 2023). However, when it comes to sexual, relational, and emotional issues, family conversations are typically avoided (Ballard & Gross, 2009). The literature highlights family conversations mostly focused on abstinence or medical prevention, aiming to prevent risks and negative consequences of sexual intercourse (Astle et al., 2022; Heels, 2019; Walters et al., 2024). The absence of CSE topics by parents seems to be due to personal factors, such as lack of knowledge, and perceived discomfort and embarrassment (Grossman et al., 2017; Holman et al., 2023), or cultural and social factors, such as generational gaps, taboos, and family dynamics (Fatemi et al., 2023; Hubble et al., 2024), resulting in a family communication often inadequate or unsatisfactory (Bruno et al., 2026; Ashcraft & Murray, 2017; Bleakley et al., 2018; Narushima et al., 2020).

This study aims to better understand family communication about CSE using a mixed-methods approach across two research phases, focusing on the perspectives of mothers, fathers, and their adolescent children. Studies show that adolescents have a positive attitude toward CSE (Alloni et al., 2017; Moreira et al., 2023; Unis & Sällström, 2020) and a willingness to access scientifically accurate information (Brunelli et al., 2022; Epps et al., 2023; Feijóo et al., 2025). Parents are cited as a source of information to address the gap in CSE education, although they are not always seen as valid or competent (Mbachu et al., 2020; McCrimmon et al., 2024). On the other hand, parents consider CSE necessary as well, but differ in their comfort levels (Gheysari et al., 2024). Specifically, the present work aims to explore family experiences of CSE in the Italian context, where recent research found that, within the family, talking about CSE is still a taboo (Save the Children, 2025).

2. Design

The work-in-progress study uses a mixed-methods, sequential approach, including two phases. The first phase included individual semi-structured interviews with three family members (adolescents, mothers, and fathers). The second phase, currently ongoing, includes administering an online questionnaire and maintaining the possibility of triadic analysis involving always three family members: adolescents, mothers, and fathers.

2.1. Objectives

The study aims to explore the perspectives of parents of adolescents (aged 18–21) and Italian adolescents on CSE within the family context. This objective arises from the following research questions: What prior experiences have Italian adolescents, mothers, and fathers had with CSE? How do adolescents and parents communicate about CSE topics within the family? Four specific objectives are identified: 1) to identify personal experiences of CSE; 2) to investigate possible educational or training needs; 3) to explore dynamics of family communication regarding CSE; and 4) to identify potential similarities and differences among participants' categories and/or within families.

2.2. Methods

The first phase included conducting semi-structured interviews, which were analyzed using reflexive thematic analysis following the steps outlined by Braun and Clarke (2019, 2021) and involving more than one coder to ensure the credibility and validity of the interpretation process (Renz et al., 2018). The families were reached first among those known to the research team, and then through snowball sampling (Gierczyk et al., 2024). The inclusion criteria for participating in this study phase were to be a family including a cohabiting adolescent, mother, and father, without distinctions in socio-economic status (SES), geographic area (Northern, Central, or Southern Italy), or sexual orientation.

The second phase will include an anonymous online questionnaire administered to parents of adolescents and adolescents (aged 18–21) in Italy. Specifically, snowball sampling (ibidem) will be used to obtain a sample composed of parents and adolescents, without distinctions in SES, geographic area, gender, or sexual orientation. The inclusion criteria will be to be an adolescent or a parent cohabiting, expanding the previous phase and including single-parent and same-sex parent families. The desired sample size (n = 300) will consist of at least 300 participants (100 adolescents, 100 mothers, and 100 fathers). Results will be analyzed using IBM SPSS Statistics. Differences in CSE experiences and family communication are hypothesized to vary by gender, sexual orientation, age, and background, particularly across high–middle–low SES and Northern–Central–Southern Italy (Killoren et al., 2024; Payne et al., 2024). As the second phase of the study is currently ongoing, the present work reports funding from the first phase.

3. Discussion

50 families participated in the first phase of the study, totaling 150 participants. Specifically, the sample included 50 mothers (age: M = 49.72, SD = 5.72), 50 fathers (age: M = 51.67, SD = 4.58), and 50 adolescents (females = 31; males = 19; age: M = 17.44, SD = 1.57). The reflexive thematic analysis identified four themes related to adolescents' sources of information and education on sexuality: Friends (n = 71), Family (n = 48), School (n = 47), and the *Web* (*n* = 35). Adolescents affirmed the positive aspects of referring to friendships as a source and experience of CSE, with peer discussions characterized by positive feelings, such as the freedom to share. However, the opposite also occurs in some cases, leading adolescents to perceive friends as not truly competent sources; as a result, they may avoid exchanges, questions, and discussions. Among the sources of information, adolescents reported the family context; however, they recalled dualistic experiences: of openness, such as discussions, exchanges of opinions, and

advice, and of avoidance or closure. The school context reveals absence and closure to CSE: Most adolescents reported experiences reflecting a lack of engagement with CSE topics in the school curriculum, even when student demand is high. However, some adolescents recall positive experiences thanks to teachers who choose to address CSE topics or thanks to experts who introduce interventions on sexuality-related issues. Finally, adolescents report using the web as an informal source of information, primarily in a direct, active manner to clarify doubts and satisfy curiosity. In some cases, the web seems to push adolescents to view content involuntarily through algorithms indirectly.

The analysis of interviews revealed similar experiences in mothers and fathers. Four themes emerged: *Absence of sources* (*n* = 74), *Self-education* (*n* = 41), *School* (*n* = 39), and *Family* (*n* = 16). Parents recall a general lack of formative and educative experiences regarding CSE topics, and to compensate for this absence, some parents report individual education through informal sources as their adolescent children – the web, friends, and peers – but also engaging in book reading and specific courses. Regarding the school context, parents of adolescents mainly recall sporadic interventions with experts, which are not always perceived positively. Indeed, the parents' educational absence reflects sociocultural taboos, transmitted even within the family through a closure of dialogue.

Deepening family communication, five themes emerged from the triadic reflexive thematic analysis: *What I talk about* (*n* = 318); *How I talk about it* (*n* = 164); *What I feel* (*n* = 132); *Who I talk about it* (*n* = 118); and *When I talk about it* (*n* = 59). Families seem to talk about, mostly, sexual health topics, recalling sexual risk prevention or general sexual issues such as identity and behaviors or sexual and romantic relationships, along with the importance of emotion management and the consent topic. Finally, adolescents and parents discuss myths and personal beliefs or sociocultural values regarding sexuality. However, they affirm a preference for sexual health topics for the present and future family discussions. Regarding how participants engaged in family communication, they mainly reported that personal experiences helped offer advice and share opinions. Some participants reported discussing sexually related issues through a scientific approach or, on the other hand, an emotional approach.

Reflecting on future discussions, participants express a preference for experiential or emotional approaches. Furthermore, adolescents and parents experience mostly positive feelings, such as happiness and comfort, in discussing CSE topics. However, embarrassment is not absent from the family's communication regarding CSE. Hence, sometimes adolescents and parents feel embarrassed; in some cases, embarrassment is linked to positive emotions like a normal feeling, and in others to negative emotions like something that can freeze the discussion. In other cases, instead, participants recall negative emotions such as anger, frustration, stress, and discomfort. Regarding the communication dynamics, both adolescents and parents seem to prefer gender-specific communication, engaging in dualistic communication based on hypothetical same-gender experiences (e.g., mother-daughter communication). Some other families, instead, seem not to engage in sexually related issues communication at all or, on the other hand, to engage all together (adolescent, mother, and father. Finally, family communication on CSE topics seems to be something that can be chosen at a specific moment, linking individual topics to adolescents' developmental phases or personal experiences. In some cases, external events and/or other experiences can help start the conversation.

4. Conclusions

People learn about sexuality within and through several contexts, experiences, and inputs (formal, informal, and non-formal). Among the wide range of stimuli on sexual issues, the family is one of them (Dyson, 2016). The present work aims to explore, in a triadic manner, the experiences and opinions of adolescents, mothers, and fathers in Italy regarding Comprehensive Sexuality Education, including their experiences of family communication. The findings corroborate the literature on the lack of education and the difficulties or dynamics of family communication. The findings provide a triadic, though not representative, overview of the Italian context and offer a starting point for rethinking and designing educational and training interventions to support families.

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THE TRIALOGICAL LEARNING APPROACH AS A TOOL FOR SUPPORTING LIFELONG LEARNING

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Abstract

The present project aims to promote innovative educational practices for both students and organizations. The theoretical framework is centered around the Trialogical Learning Approach (TLA). This integrated model is further supported by Assessment for Learning (AfL) and Sustainable Assessment (SA). The trialogical approach acknowledges the multifaceted nature of learning by integrating "monological" processes—the individual construction of conceptual knowledge—with "dialogical" processes that emphasize social interaction, intersubjective exchange, and the collaborative production of tangible knowledge artefacts that benefit the entire community. By implementing this approach, the project aims to introduce the use of Artificial Intelligence (AI) to develop essential competencies for lifelong learning, both in the training of university students and in the professional development of individuals in the corporate environment. This paper will focus on the training experiences currently being undertaken within the organization (10 participants, duration of 6 months, 30 hours), outlining the various steps involved and the initial results achieved.

Keywords: *Trialogical Learning Approach, artificial intelligence, lifelong learning, corporate professional, university students.*

1. Introduction

The present work outlines the progress of a project aimed at promoting collaborative reflective processes, drawing on the theoretical framework of the Trialogical Learning & Assessment Approach (TLA) (Grion & Sansone, 2023).

Particularly, Assessment for Learning (AfL) and Sustainable Assessment (SA) redefine evaluation as a core learning activity rather than a final step. By integrating teaching, learning, and assessment (TLA), AfL and SA emphasize the student's active role through peer-assessment, collaborative work, and the use of exemplars. The synergy promotes self-regulation and evaluative judgement, bridging the gap between formal education and lifelong learning. Ultimately, the teacher acts as a mediator in a stimulus-rich environment designed to foster the continuous "framing and reframing" of knowledge necessary for long-term professional and personal growth (Sansone & Grion, 2022).

The present research aims to explore which elements of a training model can facilitate learning and/or the consolidation of competencies in several contexts, such as universities and corporate settings. The key challenge lies in identifying the phases and aspects in which Artificial Intelligence (AI) can support learning without supplanting it. When used wisely, AI can catalyze individual agency, fostering the freedom to act and create value (Poquet & de Laat, 2021). Consequently, in exploring the pedagogical and didactic implications of democratic AI within academic contexts, we might envision AI-augmented personalized learning. Such a framework should operate holistically and sustainably, discerning when to apply or restrict personalization and when to integrate it with pluralistic approaches. In the corporate sphere, democratic application of AI could likewise facilitate educational pathways designed to mitigate job displacement. This approach prioritizes the cultivation of unique human competencies, such as creativity and intuition, the latter understood as an emotional and constructive process.

The hypothesis is that the training model can be applicable in several contexts, ranging from schools to businesses and leveraging practices known as "active methods with adults," as promoted by Mezirow (2016a) within the framework of transformative learning theory. The theoretical principle behind active methods with adults entails changing and "transforming" minds—not to condition them, but to liberate them. In particular, transformative learning describes the process of overcoming a critical moment in which an adult is forced to face their fears and uncertainties. By confronting and overcoming them, the individual "transforms" into a new and more aware person. Andragogy, as Mezirow himself puts it (2016b), comes to our aid in this arduous process, as an organized effort to assist adults with the learning process through methods that enhance self-directed learning (Demetrio, 2003).

The training project is currently underway with an Italian company, and a parallel training pathway with university students will commence in the coming months. These two cases are intended to serve as distinct yet comparable case studies.

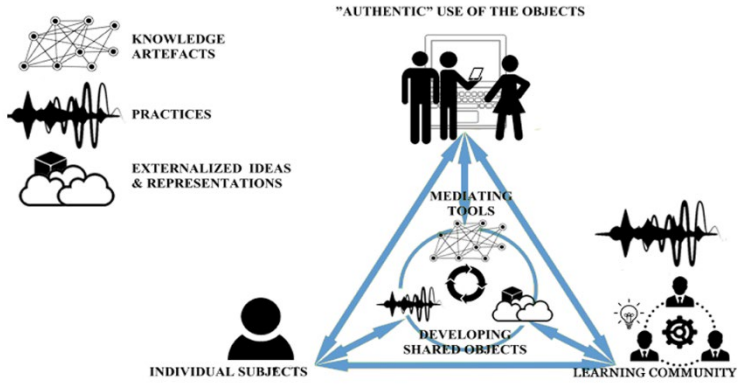
2. Design

The work-in-progress research's objectives and methodology are underpinned by the principle of lifelong learning, defined as a continuous and voluntary process of acquiring knowledge and competencies throughout one's life. A foundational premise of the present work is the recognition of AI's central role in the education of both university students and adult professionals. The AI's centrality is poised to radically reshape learning practices, from the design of instructional pathways to the development of competencies that foster professional growth.

2.1. Objectives

The work aims to explore the potentialities and limitations of AI as support for university students and corporate workers in consolidating and/or developing specific and transversal competencies. The Trialogical Learning Approach (TLA) will be employed as an active, collaborative learning method grounded in intentional cognitive acts realized through participation in targeted activities (Figure 1). Within this framework, knowledge emerges as a construction shaped by interactions with peers and experts, mediated by cultural and social artefacts—a transversal process across all ages (Paavola & Hakkarainen, 2005).

Figure 1. The Trialogical Learning Approach.



2.2. Methods

The interplay between technology and education necessitates a paradigm shift in pedagogy, leading to the emergence of digital pedagogy in recent decades. In this context, it is essential to transcend the dichotomy between learning through technology and learning about technology, fostering instead a deep understanding of digital tools that enable learning experiences that promote independence, creativity, and curiosity.

Through the analysis of field experiences, the present project aims to investigate which elements of a training model can facilitate learning and/or the consolidation of competencies across several contexts, such as universities and corporate settings. It will evaluate emerging needs and novel learning modalities grounded in participation and collaboration. Specifically, two parallel case studies will examine whether and how the proposed training model strengthens, consolidates, and uncovers soft skills, as well as the role of generative AI as a supportive tool. A secondary research challenge is to explore parallels between university student training and professional development in corporate environments.

In the university setting, a training pathway titled "AI as Tutor and Mentor" will be implemented with students in the Education Sciences bachelor's degree (L-19) at the University of L'Aquila. This will encompass theoretical sessions addressing topics such as trust in AI, source verification, and response reliability, alongside practical laboratories, for instance, on text construction—all to enable critical and aware studying with AI.

The second case involves an Italian energy engineering firm, comprising approximately 10 employees and nearly 30 years of experience in the field. The energy engineering firm's name will not be disclosed for privacy reasons. Following a thorough needs assessment, the company has embarked on an AI introduction program to acquire initial comprehension tools and gradually approach practical utilization.

3. Conclusions

Expected outcomes of this work-in-progress project include enhancements in transversal competencies, empirical evidence from parallel case studies, and long-term pedagogical impacts. Desirable measurable improvements encompass the consolidation of soft skills—such as critical thinking, collaboration, creativity, and adaptability—alongside AI-specific proficiencies, enabling most participants to engage in critical and self-aware studying or working with generative AI, including source verification and response reliability. The case studies will provide comparative evidence on the TLA model's efficacy in university and corporate contexts, highlighting parallels and validating its transversality across ages and sectors. For the corporate intervention (10 participants; 30 hours over 6 months), tangible outputs are anticipated, including AI-assisted collaborative artefacts, reduced task completion times, and scalable AI adoption plans. In the long term, the project is expected to substantiate a "trialogical digital pedagogy" framework, yielding replicable guidelines for lifelong learning pathways and mixed-methods data (pre-post tests, interviews, artefact analyses) to guide future research and dissemination via publications and toolkits.

In conclusion, the present project advances a theoretical framework centered on the Trialogical Learning Approach (TLA), integrated with AI, to foster critical competencies in both universities and corporate contexts. By connecting digital pedagogy with lifelong learning principles through parallel case studies, the research sheds light on AI's supportive role in fostering collaborative reflection, soft skills, and professional growth, without supplanting human agency. Initial findings from the ongoing corporate intervention underscore the model's potential effectiveness, paving the way for innovative, scalable educational practices capable of addressing emerging technological paradigms.

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IMMERSIVE PEDAGOGY AND EMBODIED DATA: IP AND PRIVACY RISKS IN EUROPEAN EDUCATIONAL METAVERSES

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Abstract

Immersive and metaverse-like learning environments are increasingly discussed as emerging infrastructures for higher education, particularly in relation to virtual laboratories, simulations, collaborative learning, and avatar-mediated interaction. Yet their pedagogical potential is accompanied by a complex legal and governance landscape. On the one hand, these environments operate as persistent spaces of content production, modification, and circulation, where students, teachers, institutions, and platform providers may all become implicated in questions of authorship, co-authorship, licensing, attribution, portability, and downstream reuse. On the other hand, immersive systems intensify privacy concerns because they enable the collection of dense streams of behavioural and potentially biometric data, including gaze, posture, voice, gesture, and interaction traces, from which highly sensitive inferences may be drawn. This paper argues that, in European educational metaverses, intellectual property and privacy should not be treated as distinct regulatory domains, but as interdependent dimensions of the same socio-technical infrastructure. To develop this argument, the paper proposes an analytical matrix structured around four stages of immersive learning activity: creation and remix of artefacts, platform hosting and moderation, recording and reuse for teaching and assessment, and data extraction for analytics. The framework is then applied to two scenarios: a virtual laboratory based on collaborative 3D creation and an avatar-mediated learning environment with monitoring functions. The analysis shows that the same contractual and technical affordances that organise authorship and reuse also facilitate persistent tracking, data retention, and secondary processing. The paper concludes that European educational institutions should assess immersive learning environments not only as pedagogical tools, but also as infrastructures that simultaneously distribute creative control and intensify data capture.

Keywords: *Educational metaverse, intellectual property, data protection, copyright, XR privacy.*

1. Introduction

Recent scholarship on the educational metaverse has consistently emphasized the pedagogical promise of immersive environments, particularly their capacity to support presence, embodiment, collaboration, simulation, and avatar-mediated participation in learning activities (Hwang & Chien, 2022; Zhang et al., 2022; Onu et al., 2024). These studies describe immersive educational environments as emerging ecosystems in which the boundaries between physical and virtual learning spaces become increasingly porous and where experiential, interactive, and persistent forms of participation may substantially expand the repertoire of higher education pedagogy (Hwang & Chien, 2022; Zhang et al., 2022). At the policy level, the European Commission has likewise framed virtual worlds and Web 4.0 as a strategic domain that should develop within an open, secure, trustworthy, fair, and inclusive digital environment (European Commission, 2023).

However, a purely innovation-oriented account of educational metaverses is insufficient. Immersive learning environments are not only pedagogical spaces; they are also persistent infrastructures for producing, modifying, storing, recording, and circulating digital artefacts. In this respect, they can be understood as "factories of works," since they continuously generate potentially copyright-relevant outputs such as avatars, 3D objects, virtual scenes, recordings, and composite environments. The abstract already identified this duality as central to the paper's contribution. At the same time, recent empirical work shows that privacy, digital identity, informed consent, fairness, and ethical trust are already perceived by students as significant conditions for the acceptance of metaverse-based classrooms (Al-kfairy et al., 2025).

This paper therefore argues that intellectual property and privacy are structurally entangled in European educational metaverses. The central claim is that the same platform architectures, contractual terms, and technical affordances that govern ownership, attribution, reuse, and portability also govern the capture, retention, processing, and inferential use of embodied learner data. For that reason, immersive learning should be analysed not as a neutral educational innovation onto which legal issues are later added, but as an environment in which content governance and data governance are co-produced from the outset. That argument is developed here through an analytical matrix already anticipated in the abstract.

2. Intellectual property and privacy as interlocking governance problems heading

The first dimension concerns intellectual property. In immersive educational settings, creative output is rarely discrete, stable, or attributable to a single moment of authorship. Instead, artefacts are commonly co-produced, iteratively modified, embedded within platform environments, and subsequently reused for teaching, assessment, demonstration, or institutional communication. This makes authorship and co-authorship especially difficult to determine, while also foregrounding questions concerning the scope of licences, moral-rights sensitivities, institutional reuse, and platform lock-in. Legal scholarship on the metaverse has repeatedly underlined that intellectual property disputes in these environments are shaped not only by substantive copyright doctrine but also by contractual infrastructures, avatar-related legal ambiguities, and the practical redistribution of control through platform governance (Cheong, 2022; Vig, 2022). In the educational context, the key issue is therefore not simply who created a virtual artefact, but who may store it, alter it, display it, relicense it, or prevent its export to another environment.

The second dimension concerns privacy and data protection. A growing body of XR scholarship shows that immersive environments are capable of collecting highly granular streams of non-verbal and behavioural information, including movement patterns, spatial relations, gaze trajectories, body posture, and interaction habits (Giaretta, 2025; Hine et al., 2024). Survey work on VR privacy and security stresses that these systems collect precisely the forms of non-verbal information that can reveal user preferences, behavioural patterns, and performance traits (Giaretta, 2025). More importantly, behavioural-biometrics research has shown that identification in VR can be inferred from body motion and relational movement patterns, while subsequent work has confirmed the feasibility of identifying users from behavioural traces even under conditions of normalization (Pfeuffer et al., 2019; Liebers et al., 2021). Recent work in Social VR has gone further, showing that eye-gaze behaviour alone can identify users with very high accuracy (Rubo & Son, 2025). The legal significance of these findings is substantial, because they suggest that data often presented as merely functional or non-identifiable may, in practice, support re-identification, profiling, or sensitive inference.

In the European legal framework, this concern is sharpened by the GDPR. The Regulation defines biometric data as personal data resulting from specific technical processing relating to physical, physiological, or behavioural characteristics that allow or confirm the unique identification of a natural person, and it treats biometric data used for uniquely identifying a person as a special category of data (European Parliament and Council of the European Union, 2016, art. 4(14), art. 9). The GDPR also requires a data protection impact assessment where new technologies are likely to generate high risks, including where personal data are processed for systematic and extensive evaluation of personal aspects based on profiling (European Parliament and Council of the European Union, 2016, art. 35). This matters for educational metaverses because recording, monitoring, learning analytics, and avatar-mediated assessment may all combine to produce forms of systematic observation that exceed what is ordinarily associated with standard e-learning environments. At the same time, the DSM Directive confirms that digital teaching uses are legally significant within the EU copyright framework and that contractual provisions contrary to the teaching exception are unenforceable, thereby making the relation between copyright rules and platform contracts especially important for educational institutions (European Parliament and Council of the European Union, 2019, art. 5, art. 7).

3. Analytical framework and method

To capture this interdependence, the paper develops an analytical matrix structured around four stages in the lifecycle of immersive learning activities: creation and remix of artefacts; platform hosting and moderation; recording and reuse for teaching and assessment; and data extraction for analytics. For each stage, the framework examines the relevant IP nodes—authorship, co-authorship, license scope, attribution, moral-rights concerns, portability, and downstream reuse—alongside the relevant privacy nodes—data categories, telemetry, biometric or quasi-biometric potential, inference pathways, retention, secondary use, and controller–processor allocation. The purpose of the matrix is not merely classificatory. Rather, it is designed to expose the points at which content governance and data governance become inseparable in practice.

Methodologically, the paper combines doctrinal legal analysis with a socio-technical reading of immersive platforms. The doctrinal layer relies primarily on EU copyright and data-protection sources, while the socio-technical layer is informed by recent scientific literature on immersive learning, XR privacy, behavioural biometrics, and metaverse ethics (Hwang & Chien, 2022; Zhang et al., 2022; Giaretta, 2025; Hine et al., 2024). This combination is important because many of the most significant risks in immersive education do not arise from formal legal categories alone, but from the way in which platform design, monitoring tools, default settings, retention systems, and terms of service operationalise those categories. The framework is then tested through scenario-based application to two use cases already identified in the abstract: a virtual laboratory involving collaborative 3D creation and an avatar-mediated learning environment incorporating monitoring features.

4. Scenario analysis

The first scenario concerns a virtual laboratory in which students collaboratively create and manipulate 3D artefacts. From a pedagogical perspective, such a setting exemplifies the educational value of the metaverse: it supports experimentation, shared construction, situated problem-solving, and persistent access to co-created resources (Hwang & Chien, 2022; Onu et al., 2024). Yet the same scenario immediately raises legal questions. If students jointly build virtual objects, textures, or scenes, it may be unclear whether the resulting artefacts should be treated as individual or collective works, how attribution should operate, whether institutional reuse requires further authorization, and how far platform terms extend over stored or exported content (Cheong, 2022; Vig, 2022). Simultaneously, the platform may log fine-grained interaction data about who manipulated which object, when, for how long, with what degree of success, and in what sequence. In other words, the infrastructure that preserves and organises collaborative authorship also preserves and organises behavioural visibility.

The second scenario concerns an avatar-mediated learning and assessment environment with monitoring functions. Here the legal entanglement becomes even clearer. Avatar-based participation may generate a range of potentially protectable artefacts, including customized avatars, recorded performances, virtual presentations, shared spatial arrangements, and session captures (Cheong, 2022). At the same time, assessment features may rely on voice data, gaze direction, posture, gesture, timing, and other interaction metrics that can become proxies for attention, credibility, engagement, or competence. Recent research on user identification in immersive environments underscores how easily seemingly routine behavioural data can become identifying or inferentially rich (Pfeuffer et al., 2019; Liebers et al., 2021; Rubo & Son, 2025). In educational contexts, this is especially problematic because students are rarely situated as fully autonomous market actors; rather, they participate within an institutional relationship marked by dependency, evaluation, and limited bargaining power. The result is that monitoring functions may simultaneously expand institutional control over both educational content and embodied learner data.

5. Discussion and conclusions

The analysis confirms the paper's core claim: in European educational metaverses, intellectual property and privacy are not merely adjacent concerns but mutually reinforcing dimensions of the same governance problem. What appears, from one angle, as a question of authorship, licensing, or reuse often appears, from another, as a question of telemetry, retention, profiling, or secondary processing. The literature on immersive education already points to privacy, ethics, and trust as central conditions for sustainable adoption (Al-kfairy et al., 2025), while XR scholarship increasingly demonstrates that movement, gaze, and other embodied signals can become identifying and inferentially sensitive (Giaretta, 2025; Hine et al., 2024; Rubo & Son, 2025). Legal analysis of metaverse environments, in turn, shows that rights allocation and platform control are inseparable from broader questions of responsibility and user protection (Cheong, 2022; Vig, 2022). Taken together, these strands of scholarship support the conclusion

that the educational metaverse should be treated as a legally dense infrastructure rather than as a merely innovative teaching tool.

For European educational institutions, the practical implication is straightforward. Decisions to adopt immersive platforms should be preceded by close scrutiny of platform terms, clear internal governance over authorship and reuse, restrictions on recording and secondary processing, and rigorous DPIA-oriented assessment wherever behavioural monitoring or analytics are involved (European Parliament and Council of the European Union, 2016, art. 35; European Commission, 2023). The most important lesson is therefore institutional rather than technological: immersive learning environments redistribute rights and responsibilities across students, teachers, institutions, and providers, and that redistribution must be governed explicitly. A European approach to educational metaverses should consequently combine pedagogical ambition with legal caution, ensuring that innovation does not normalize opaque ownership structures or excessive capture of embodied learner data.

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ECOLOGICAL IMPERATIVE AND CO-EVOLUTIONARY EDUCATION THROUGH METHODOLOGICAL SYNTHESIS

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Abstract

Modern higher education requires a strategic shift toward student-centered and competence-based approaches, as emphasized by the Bologna Process and recent EHEA communiqués. A critical challenge remains the formation of educational content that bridges the gap between fundamental theories and professional practice. This research, supported by the Institute for Human Sciences (IWM) under the Documenting Ukraine grant, proposes an integrated approach to modernize environmental education, specifically through the lens of regional water security. The study's objective was to create an effective didactic system that systematizes knowledge of natural-science theories while addressing urgent global and, crucially, regional water problems. For listeners, the issue of water security is particularly valuable when examined through a regional perspective, as it allows them to connect abstract global Sustainable Development Goals with the tangible ecological state of their own local basins and communities. The "Water Security" course serves as a primary example, integrating international water policy with regional environmental management into a cohesive module. The methodology employed included component analysis of ecological knowledge, educational experiments, and mathematical statistics to evaluate the completeness of knowledge acquisition. By focusing on regional cases—such as the pollution of local rivers or the depletion of water—students develop a co-evolutionary worldview and a deeper sense of professional responsibility. This localized approach ensures that the "ecological imperative" becomes a practical guide for future specialists rather than a theoretical concept. The essence of methodological synthesis in the content of education is to create a holistic didactic system that not only combines knowledge from different disciplines, but also ensures their interaction at the highest level - through the coordination of fundamental natural science theories, basic categories and principles. The study involved three years of experimental validation with over 600 listeners, demonstrating high didactic effectiveness. Results showed that students achieved an average knowledge acquisition coefficient of 0.85, significantly exceeding the satisfactory threshold. The integrated approach was implemented across three levels: internal disciplinary, interdisciplinary, and methodological synthesis. In conclusion, the integrated approach to "Water Security" not only improves the quality of professional training but also fosters environmental stewardship. By emphasizing the regional dimension of water problems, this model helps students master the complex international and local dimensions of environmental policy. Future research will focus on improving assessment methodologies for these integrated modules to ensure the continuity of educational objectives in a changing global climate.

Keywords: *Ecological imperative, co-evolutionary worldview, methodological synthesis, environmental responsibility, knowledge acquisition.*

1. Introduction

Improving the content of education as a strategic priority and a key direction of higher education reform the 2015 Yerevan, 2018 Paris, and 2020 Rome Communiqués identified improving educational content as a strategic priority for European higher education reform (Ministerial Conference Yerevan, 2015; Ministerial Conference Paris, 2018; Rome Ministerial Communiqué, 2020). In line with these EHEA recommendations, Ukrainian institutions must shift toward student-centered and competence-based approaches, emphasizing innovation, stakeholder dialogue, and empirical research (Rome Ministerial Communiqué, 2020).

Educational content is defined as a system of scientific knowledge, skills, and moral-aesthetic ideas mastered during learning (Munawaroh, 2017; Pawley, 2019). Its formation is a complex

methodological challenge influenced by technological progress, societal needs, and state policy (Cheung & Slavin, 2016; Kosmutzky & Nokkala, 2020; Little & Green, 2009).

Integration has emerged as a primary trend in overcoming the limitations of traditional disciplinary approaches. Today, this manifests in several forms:

- Interdisciplinary research at the boundaries of related fields.
- The application of general systems theory, cybernetics, and synergetics.
- Solving complex global issues, such as environmental crises, which require multi-disciplinary participation (Ampatzidis & Ergazaki, 2017; Ampatzidis & Ergazaki, 2018; Bezsonov et al., 2017; Menashy & Verger, 2019).

Ukraine's integration into the European Higher Education Area necessitates a change in educational philosophy. 21st-century culture demands professionals focused on innovation and human values (Mitryasova et al., 2020; Mitryasova & Pohrebennyk, 2020; Munawaroh, 2017). Natural science education, in particular, has the potential to address sustainable development through integrated courses and holistic knowledge structures (Mitryasova, 2020). To address these needs, research suggests a reorientation of curricula toward integrated issues (Mitryasova et al., 2017). As a practical example, we have developed an interdisciplinary training course to solve issues of understanding sustainable development.

The purpose of research is the creation of an effective didactic system through the integrated approach of a natural education, for example of water security course with a special emphasis on professional orientation.

The object is the natural education content of the students' preparation process, namely, students' training in the environmental specialty.

The subject of the research is the content of the interdisciplinary course on water safety for students of environmental specialties of universities.

2. Methods

To develop and evaluate the integrated training course, a multi-faceted methodology was employed, ranging from partial scientific approaches (such as component analysis of ecological knowledge and postoperative skill analysis) to general scientific methods like educational experiments and mathematical statistics. These methods facilitated the selection of curriculum material and the analysis of experimental data.

To measure students' proficiency, the study assessed the ratio of concepts correctly applied by students against the total possible definitions. While tasks primarily targeted the reproductive level of learning, the specific quantitative measure used to evaluate the depth of student understanding was the knowledge acquisition coefficient (Mitryasova, 2020).

3. Discussion

The modern paradigm of environmental education for Master's students is built upon a structured integrated approach, which functions as a specialized framework for designing educational content. This methodology transcends traditional disciplinary boundaries by coordinating and systematizing knowledge around core natural-science theories, basic categories, and a holistic scientific picture of the world. By implementing this approach, the curriculum effectively bridges the gap between theoretical knowledge and the practical necessity of making optimal management decisions.

The selection and structuring of educational material are guided by several foundational principles. These include the principle of systematicity, where the goals of natural science education are aligned with leading laws and theories, and the principle of fundamentalization, which ensures deep academic rigor. Furthermore, the content is heavily shaped by professional orientation, focusing on interdisciplinary connections that address urgent global challenges. Central to this framework is the disclosure of environmental crises, specifically climate change, sustainable development, and the deteriorating state of water resources (Bezsonov et al., 2017; Mitryasova & Pohrebennyk, 2020).

The practical application of the integrated approach occurs across three hierarchical levels. At the intradisciplinary and interdisciplinary levels, integration is achieved through the careful selection of facts, concepts, and methods tailored to specific specializations and humanistic values. At the highest level—methodological synthesis—the focus shifts to dialectical categories such as systems, structures, causality, and patterns. This synthesis allows students to perceive the relationship between elements and their consequences within a broader environmental context.

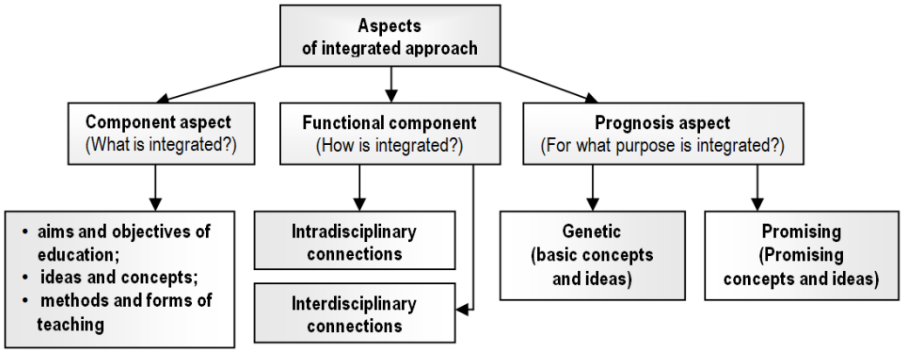
A primary example of this methodology is the Master's training course in Environmental Science, which prioritizes European practices in the field of water security. The course content is rooted in the

environmental imperative and the concept of co-evolutionary development between society and nature. By exploring topics such as integrated water management, environmental law, and pollution issues, the curriculum fosters a sense of responsibility for the quality of natural resources (Mitryasova & Pohrebennyk, 2017). Ultimately, this integrated model enhances students' awareness of European studies and equips them with the expertise to navigate the evolution of environmental management within the European Union.

The curriculum is built upon a robust interdisciplinary foundation, merging the core tenets of sustainable development strategies with extensive European experience in environmental water policy (Mitryasova, Koszelnik et al., 2020; Mitryasova & Pohrebennyk, 2020). By focusing on the integration of environmental requirements into diverse policy sectors, the course covers critical issues such as water monitoring, pollution control, purification technologies, and climate change. Furthermore, it incorporates an essential international dimension, examining the European Union's leading role in global environmental movements—including the Kyoto Protocol and the UNESCO Roadmap—and assessing the broader impact of European policy on global water security networks.

The practical execution of this integrated approach is governed by three primary analytical aspects: the component, functional, and prognosis dimensions. The component aspect addresses the fundamental question of *what* is being integrated, identifying the specific scientific elements and data points brought together. The functional aspect explores *how* integration occurs by facilitating the active operation of intra- and interdisciplinary connections. Finally, the prognosis aspect serves a dual purpose: the *genetic* area examines the origins of basic scientific concepts, while the *prospective* area identifies promising ideas and future trends in environmental management. This multi-layered framework ensures that students not only acquire current knowledge but also develop the capacity to anticipate and respond to evolving ecological challenges (Figure 1).

Figure 1. The most important aspects of integrated approach.



The course is interdisciplinary and connects the policy and tools of water monitoring and management, principally addressing EU and Ukraine practices of water quality, water resources, biodiversity, and, fisheries and their progressive integration.

Table 1. The main content of the course.

Topic	Main issues of the topic
The role of the EU in international environmental motions (e.g. Kyoto Protocol, UNESCO Roadmap for Implementing the Global Action Programme on Education for Sustainable Development, Sustainable Development Strategies).	History of the formation of the EU environmental foundation; the EU's place in international environmental law; EU institutions in the field of environmental protection; legal support for the concept of "sustainable development" in the EU.
The strategies of EU environmental policy.	General characteristics of EU environmental policy; the United Nations Environment Programme; UN climate conferences and the EU position; United Nations Environment Programme (UNEP), UN Climate Change Conferences: Bali, Poznan, Copenhagen, Cancún Transatlantic relations and climate change / EU & US relations on environmental issues.

Water and development in Europe: environmental sustainability as a precondition of European environmental policy and its best practices in water monitoring.	Water in numbers and facts; water Framework Directive as the main document for water monitoring; status of water resources; types of state water monitoring; a new order of water monitoring in Ukraine; comparative analysis of the monitoring format: as it was and how it will be; European experience in water monitoring.
Implementation of sustainable development programs to post-soviet countries.	Characteristics of sustainable development content from the UN's views; the role of ecological security in the sustainable development; environmental security of aquatic ecosystems: priority factor in development; assessment of environmental component in the region's development; effectiveness of the implementation of sustainable development programs in the post-soviet countries.
Water resources, water quality and climate change.	The water-resource potential of the hydrosphere; distribution of water resources; water resources of Ukraine; factors of formation of water composition; properties of natural waters; general requirements for drinking water quality in the world; requirements for water quality in Ukraine; drinking water and human health; adaptation to climate change.
Integrated water management: challenges for the 21st century.	Water is the matrix of life; regional aspect of water supply: history question; characterization of water treatment stages; EU experience.
Water policy and law: a comparative analysis of European and Ukrainian practices.	Water is the global agenda of the United Nations; integration is a key trend in water management; integrated flood risk management; integrated water resources management by basin principle.
Urban water services: practices of developed European countries.	Water supply systems: circulating water supply; centralized drinking water supply; local or decentralized water supply; cold and hot water supply; Ukrainian experience of normalization of drinking water quality; where can we drink tap water? Experience of EU; drinking water quality standards in Ukraine and EU countries.
Basics of freshwater ecology. The best practices in water purification in the EU member states.	Water policy on the definition of international waters; international water management experience; a sphere of EU influence on water policy formulation; principles of sustainable water management in Ukraine.
Challenges for Ukraine in water security policy and practice due to association with the EU.	The water footprint of the country; the Urban Waste Water Directive; urban wastewater treatment plants; urban sewage treatment technology; the Marine Strategy Directive; the Drinking Water Directive; the Flood Directive; the Nitrate Directive.

A test form of knowledge control was used to assess the completeness of mastering the content of educational material. The test tasks included questions of the reproductive level regarding the key concepts of the training course.

The lower limit of availability is taken as a coefficient of 0.6, which corresponds to a satisfactory level of knowledge. Based on the obtained data, the quantitative processing of the results, which was carried out for each year (the experiment was conducted for three years), and then the average data were derived. It is proved that the selected educational material is quite fully assimilated by students, as evidenced by the average coefficient of 0.85.

To test the strength of knowledge and determine the degree of forgetfulness, a slice of knowledge was performed two weeks after studying the course. The coefficient of knowledge strength was defined as the ratio of the number of elements of knowledge that remained in the memory of students after some time to the sum of the elements of knowledge contained in the test. It is established that more than half of the knowledge remains in the memory of students. It is determined that the degree of forgetfulness is 3−5% of the previous ones. Thus, in the process of forming students' knowledge, the tendency to increase their educational activity, interest in carrying out independent scientific research, in expressing original views on environmental issues discussed during classes was determined.

4. Conclusions

In conclusion, the integrated approach to "Water Security" not only improves the quality of professional training but also fosters environmental stewardship. By emphasizing the regional dimension of water problems, this model helps students master the complex international and local dimensions of environmental policy. Future research will focus on improving assessment methodologies for these integrated modules to ensure the continuity of educational objectives in a changing global climate.

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ASSESSMENT OF AI IMPACT ON LECTURES AND THESES IN UNIVERSITY EDUCATION

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Abstract

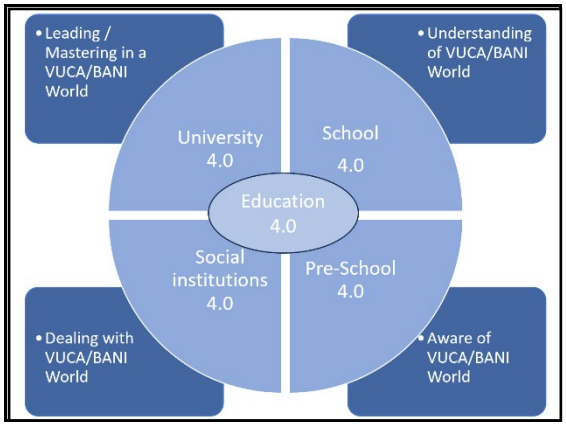
Since the release of ChatGPT, generative AI has become more and more important almost in all areas in society, which includes university education. How can AI support professors in teaching and students in their preparation of thesis? How can the interactions be improved in an AI world between professors and students? To answer these two research questions, two lectures have been evaluated with different AI focus: 1) Management of modern technologies with focus on group workshops in which students discuss virtual in breakout sessions by using and avoiding AI; and 2) Digital transformation with focus on individual preparation of project documents to presentation in video according to Elevator Pitch method. Each of 2 typical Master and bachelor theses have been assessed regarding AI helps and differences of quality. The results of this paper recommend the critical but selective and comparative use of AI both in lectures and theses to enhance the interaction between professors and students in universities.

Keyword: *University education, AI, lectures, theses, interactions.*

1. Introduction

In times of VUCA/BANI environments, the education sector faces numerous challenges, particularly since the release of ChatGPT in November 2022. In Wang R. & Contino G. (2024), the concept of Education 4.0 was discussed extensively, see Figure 1.

Figure 1. Education 4.0 in connection with VUCA/BANI (An evolution from a VUCA-appropriate to a BANI- appropriate framework, Wang R. & Contino G. (2024).



Within this framework, the concept of University Education 4.0 emphasizes the educational objective of *"Leading and Mastering in a VUCA/BANI World,"* recognizing that today's students will become the leaders of tomorrow.

Against this background, it becomes increasingly important for professors and students to collaboratively define learning objectives and establish a mutual understanding regarding the appropriate use of artificial intelligence methods — both in classroom / digital teaching and in the supervision of academic theses.

Based on a targeted analysis at both bachelor's and master's levels, two digitally supported courses in modern formats were examined:

- *Management of Modern Technologies* for master's students in IT Management, and
- *Digital Transformation* for bachelor's students from various academic disciplines.

In addition, bachelor's and master's theses were systematically analyzed with regard to the application and integration of AI technologies.

From this context, the following research questions emerge:

1. How can AI support professors in teaching and students in the preparation of academic theses?
2. How can interactions between professors and students be improved in an AI-driven educational environment?

2. Samples from lectures

In recent years, lectures at universities have become increasingly digitalized. On the one hand, this development was accelerated by the COVID-19 pandemic; on the other hand, it has been significantly enabled and advanced by generative artificial intelligence technologies.

The selected courses analyzed in this study were conducted at the FOM University of Applied Sciences.

2.1. Management of modern technologies

This module is designed for first-semester master's students in the IT Management program. The course is conducted entirely in a digital teaching format. Most students already possess several years of professional work experience and demonstrate strong IT competencies. They are generally highly familiar with the use of AI technologies and have often already gained experience with AI applications during their bachelor's studies and bachelor's thesis projects.

The module consists of both theoretical and practical components. The theoretical part covers topics such as technology management, innovation management, and modern technologies including artificial intelligence, quantum computing, and SmartX technologies (see Wang, 2025). The practical component includes group work based on real application scenarios of modern technologies.

Typically, around 50 students participate in the course, allowing multiple groups to be formed for collaborative project work.

2.1.1. Group work example. Hereafter is a typical sample of group work in this module:

Work in groups (breakout sessions) on the following topics:

- Industry 4.0 vs. Made in China 2025
- Industry 5.0 or Industry 4.1
- IoT vs. IIoT

1. Analyze the differences and specific challenges, taking into account technological, ethical, and organizational aspects. Identify at least three key challenges.
2. Develop appropriate solutions for the identified challenges. Provide concrete recommendations for action and outline measures for how these challenges can be addressed.
3. Present your findings (10 min. per group).

In the early stages of the course, the professor is very pleasantly surprised by the well-prepared presentation; not only is the content solid and comprehensive, but the presentation slides are also of high quality — even though students were instructed not to use AI in their group work so that group members could discuss the material intensively.

At the end of the semester, some students report that AI was used almost always in the group work. The added value of the discussion is not fully realized. For this reason, the group work in this example was adjusted as follows:

Assuming there are 5 students in the group, the tasks were reformulated as follows:

Work in groups (breakout sessions) on the following topics:

- Industry 4.0 vs. Made in China 2025
- Industry 5.0 or Industry 4.1
- IoT vs. IIoT

1. Four of you use different AI tools: ChatGPT, Perplexity, DeepSeek, Gemini. One student works without AI.
2. Each group has the same task:
    - Analyze the differences and specific challenges, taking into account technological, ethical, and organizational aspects. Identify at least three major challenges.

- Develop appropriate solutions for the identified challenges. Provide concrete recommendations for action and outline measures for how these challenges can be addressed.

3. Compare and analyze the results from various AI tools and those produced by the students without using AI tools.
4. Present your findings (10 minutes per group).

2.1.2. Key results. The example described above is just one of more than 10 group exercises in this module in which students repeatedly use AI. By adapting the exercises to include the deliberate use of AI, students can observe the varying results produced by different AI tools and assess their reliability for themselves through discussion. An important aspect is the work produced by students without the use of AI. This clearly highlights the advantages of AI — comprehensiveness and systematic approach—as well as its disadvantages: some incoherent results or overly interpreted data from websites.

This approach also fosters greater trust between students and professors.

2.2. Digital transformation

The module is designed for various Bachelor of Arts and Bachelor of Science degree programs. There are often more than 70 students, even though a maximum of 60 students is allowed per course. This high demand also demonstrates how important the topic of digital transformation is. Students from the following degree programs attend the module: Business Informatics, Management and Digitalization, International Management, Social Sciences, Healthcare, Digital Media and Marketing, Business Administration, etc.

For this reason, students have diverse technical and academic backgrounds and hold varying expectations. The module includes numerous exercises. It is consistently noticeable that students tend to rely on AI during exercises because they have limited familiarity with the subject matter. This also means they are not always able to assess whether the AI results are accurate, which could pose a risk to their education.

The module is taught digitally, in person, or in a hybrid format. The content is primarily drawn from Wang R. (2019, 2024, 2026). Typical topics include digital strategy, digital mindset, digital management, and digital technologies. The course covers Transformation Canvas, Digital CRM, Design Thinking, and other methods. For the final assessment, students are required to submit a sales video (elevator pitch) along with explanatory supporting material.

2.2.1. Exercise example. Hereafter is a typical sample of group work in this module:

Exercise and Presentation

Develop a business idea related to your professional field, formulate two key hypotheses, and outline a quick validation strategy to test your idea.

1. Brainstorming: In small groups, develop a business idea that solves a specific problem.
2. Describe:
    a) The problem (in one sentence).
    b) Your target audience (Who is affected?).
    c) Your solution (in one sentence).
3. Formulating hypotheses: Formulate two key hypotheses regarding your business idea.
    a) Problem hypothesis: Does the problem actually exist?
    b) Solution hypothesis: Would your target audience use your solution?
4. Validation strategy: Draft a quick plan for how you could test one of the hypotheses.
    a) What method will you use (e.g., survey, landing page, interview)?
    b) Who would you survey or involve?
5. Presentation of results: Present your business idea, hypotheses, and validation strategy.

2.2.2. Key results. In order not to use AI, the exercises should be designed with strong relations to the professional activities of students. Through such real cases students should be able to think about their business life and remain creative.

The example above also demonstrates the direct benefits for students, as it allows them to solve a current problem in their field without relying on AI, but rather through direct interaction with other students, and then receive feedback from the professor during the presentation.

3. Samples from thesis

Over 50 theses (since 2023) have been evaluated in the context of this publication; these were produced with varying degrees of AI involvement. If students have written a thesis with the help of AI, they must cite the AI sources in accordance with the FOM's AI guidelines; see the Rector's Office (November 15, 2023). In principle, authenticity and integrity are always maintained by students when AI is used. Below, two positive examples are evaluated, which clarify when the use of AI in a thesis is appropriate and when it is not, from the perspective of the supervising professors.

3.1. Master thesis

Steffen D. (2026) has written an excellent master's thesis that addresses an interdisciplinary topic at the intersection of medicine, law, and computer science: an experimental study on patients' perceptions of AI in dermatology. In this master's thesis, which spans over 100 pages, a range of scientific methods were employed, including literature review, study design and experimental manipulation, data collection and measurement instruments, sampling and recruitment, statistical analysis using R, and ethical considerations. In principle, all of these methods can be applied and optimized using AI. However, that would no longer constitute an independent scientific work.

In this master's thesis, AI was applied in areas where it was appropriate. Table 1 provides an overview and analysis of mater Thesis of Steffen D. (2026):

Table 1. Areas with usage of AI and not.

Topics in thesis	AI used?	Which AI?	If AI used?
Language Grammar	Yes, this is just a check of spelling, punctation and simple grammar, not real creative work.	DeepL Write	
Advertisement with fictive portraits	Yes, this is only a simulation of a dermatological station, in order to avoid any personal data which is strongly protected in Germany.	Google Gemini 3	
Online survey	No		AI can be used to generate data. If used, then the data are not real and the results are not the own. This would be inacceptable.
Literature study	No		Students often use AI to research in literature if the correct algorithm is written. However, Literature study is an important research activity, especially if the topics are interdisciplinary.
Interviews	No		Students could use AI to generate expert interviews which happen sometime in courseworks. But experts often need interaction with interviewer and this cannot always follow a given manner.
Citation	No		Index of citation can be generated automatically, but only index, not the use of citation in the text and footnotes.
Programming R	No		Nowadays AI generates codes without bis issues. However, R is used for statistical analysis and the parameter must be checked and correct so that the following steps with analysis can be correct.
Statistical analysis	No		This is a very crucial part in the thesis and provides basis for the answer to the research questions. If AI were used, the thesis could fail, based on current code of conduct.
Presentation of results	No		If a perfect presentation is generated by AI, but the contents are from the author, this could be accepted, because power point is also a tool for layout.

3.2. Bachelor thesis

Ruhstorfer, R. (2024) explores a very interesting topic: how concertgoers experience a live concert even when the artist is not physically present. The occasion for his study was "Falco – In Concert" at the New Year's Eve party in Vienna in 2024. Before the performance, the host mentioned that Falco would be performing "live" on stage later. It became clear relatively quickly that Falco would not be on stage in person, but rather his original band. Acting as his representatives, contemporary artists performed his songs with a slightly different musical touch, yet staying true to the original.

To investigate the acceptance of such a concert, Ruhstorfer, R. (2024) simulated an event using augmented audio. He interviewed audience members using software tools and analyzed their experiences. Ultimately, he was able to answer his research questions: "How do users perceive the simultaneous audio output of different sounds from two channels?" At the same time, he also used the Design Science Research (DSR) method to answer his other research question: "How can the audio output of a virtual performer be technically realized and played back in sync with the audio output of a live performer?"

Since the creative idea was developed by the author — which constitutes the core of the thesis — the student used 3 AI tools to simplify the necessary supplementary work in his thesis. In addition to ChatGPT, he used noScribe, version 0.3, and udio, model 1.5, as he also indicated.

The tool "noScribe" was used for an initial transcription of the audio files. After using the tool, it was found that this transcription was still very error-prone in some parts and had to be manually corrected. Especially with dialectal pronunciations, the tool cannot transcribe without errors, and the author had to make many manual corrections. The AI tool Udio was used to generate music, resulting in two compatible music files that can be played in parallel and complement each other. The prompts for this were relatively simple, so the first attempt immediately produced two suitable audio elements. The AI chatbot ChatGPT was used to obtain assistance with programming the artifact and to correct errors in the code.

All prompts for the AI tools have been attached to the bachelor's thesis for verification.

4. Conclusions

AI has become indispensable in nearly all areas of science and teaching. For this reason, students should not be prohibited from using AI. On the other hand, creativity and group discussions must not be neglected. Therefore, AI applications in teaching should be proactively incorporated into the curriculum, and students should be encouraged to critically evaluate AI results and use them to inform their learning.

The two research questions can be answered positively based on the examples and analysis from the lectures and the theses.

To the research question: How can AI support professors in teaching and students in their preparation of theses? The answer lies in constant coordination between students and professors. When it comes to the core of the thesis — such as independent and creative work — AI should be used as little as possible. In the supporting sections, AI can be used, especially since all these must be completed within a specified timeframe.

To the research question: How can interactions between professors and students be improved in an AI-driven world? The key to answering this research question lies in interaction and the trust between professors and students. On the one hand, students must be encouraged to use AI in exercises — and to use it correctly; on the other hand, exercises can be designed so that solutions can only be derived from practical experience.

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EXPLORING THE UTILITY OF EXTENDED REALITY IN RURAL MEDICAL EDUCATION: A PROGRAMMATIC RESEARCH SYNTHESIS

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Abstract

Extended reality (XR), including virtual reality (VR), mixed reality (MR), and 360° video, has emerged as a promising approach for enhancing simulation-based medical education (SBME), particularly in rural and distributed healthcare settings where access to training is limited. This paper reports on a programmatic research synthesis to integrate findings from a series of related studies examining the development, implementation, and evaluation of XR technologies for neonatal resuscitation and rural healthcare education. The synthesis included five studies conducted within a coordinated research program using complementary qualitative, quantitative, and development methodologies. Participants across studies included physicians, nurses, respiratory therapists, and allied health professionals. Data sources included interviews, surveys, pre- and post-tests, performance assessments, and observational data. Four overarching themes emerged from the synthesis. XR technologies demonstrated strong educational value, with VR simulation improving confidence, perceived usefulness, and performance in neonatal resuscitation skills. XR environments enhanced immersion and experiential learning, with participants reporting strong presence and engagement. XR technologies improved access to training, particularly for rural healthcare providers, by reducing travel requirements and supporting flexible, repeatable learning opportunities. Implementation challenges included technical limitations, infrastructure requirements, and the absence of tactile feedback. Overall, findings suggest that XR technologies offer a promising complementary modality for SBME and continuing professional development (CPD). XR-based approaches may enhance access to training, improve learner engagement, and support skill development in rural healthcare settings. Further research is needed to examine long-term educational outcomes and implementation strategies across diverse healthcare environments.

Keywords: *Extended Reality (XR), Head-Mounted Display (HMD), Simulation-Based Medical Education (SMBE), medical education, rural education.*

1. Introduction

The sustainability of rural healthcare systems is increasingly threatened by shortages of healthcare providers and difficulties in recruiting and retaining physicians in rural communities (Asghari et al., 2020; World Health Organization, 2010). Rural populations also face poorer health outcomes and greater healthcare needs compared with urban populations, further increasing the demand for well-trained rural healthcare professionals (Curran & Rourke, 2004; Welton et al., 2025). Healthcare professionals working in rural and remote environments face unique challenges in managing diverse clinical presentations while maintaining competence in procedural skills that may be used infrequently (Curran & Rourke, 2004; Curran et al., 2010). In this context, ongoing access to continuing professional development (CPD) is essential for delivering safe and effective care, especially given the broad scope of practice required in rural settings.

CPD includes the various educational and developmental activities healthcare providers undertake to maintain and improve their knowledge, skills, performance, and relationships in healthcare (Kitto et al., 2013; Shannon, 2003). For many regulated healthcare providers worldwide, CPD participation is mandatory during the lengthy post-licensure period of their careers. It is seen as a crucial way to stay current with evidence-based practices in their field and maintain clinical skills. Evidence shows that healthcare providers who participate in formal CPD activities tend to deliver higher-quality care than those who do not (Al-Ismail et al., 2023; Kitto et al., 2013). However, access to CPD is a key factor affecting recruitment,

retention, and professional satisfaction among rural healthcare providers. Geographic isolation, travel requirements, and limited educational opportunities create significant barriers to CPD participation (Curran et al., 2006; Curran et al., 2010). These barriers underscore the importance of innovative educational solutions to help rural healthcare providers maintain their competencies.

Simulation-based medical education (SBME) modalities have been shown to effectively support clinical skill development (Elendu et al., 2024). However, simulation centres are usually located in urban areas, which limits access for practitioners in rural regions. Extended reality (XR), including virtual reality (VR), augmented reality (AR), and mixed reality (MR), offers engaging learning environments that may help address these challenges (Curran et al., 2022). XR technologies enable learners to participate in simulation-based training without travelling to centralized facilities, making them especially relevant for rural and distributed education contexts. They provide immersive learning environments that replicate clinical scenarios, allow repeated practice, and offer flexible training opportunities that can be delivered across geographically dispersed locations. Given these benefits, XR is particularly well-suited to rural healthcare education because it reduces travel requirements and supports distributed learning.

This paper provides a synthesis of a research program examining the effectiveness, perceived educational value, and feasibility of XR to improve CPD and training in rural medical education.

2. Methods

This study used a programmatic research synthesis to summarize and combine findings from a series of related studies examining the development, implementation, and evaluation of XR technologies for neonatal resuscitation and rural healthcare education. Programmatic research synthesis involves combining findings across a coherent body of research to generate wider insights beyond individual studies. The included studies were conducted between 2000 and 2026 and employed qualitative, quantitative, and mixed-methods approaches. Study findings were reviewed and compared to identify common themes and overarching insights. This approach enables integrating findings across studies to develop a broader understanding beyond individual investigations.

2.1. Context

Memorial University's Faculty of Medicine has a longstanding international reputation for leadership in rural medical education, influenced by Newfoundland and Labrador's geography and a strong social accountability mandate. From its early years, the faculty adopted a distributed, community-based education model, embedding learners and faculty across rural and regional sites. Memorial is also a Canadian pioneer in telemedicine and tele-education, establishing one of the country's earliest telemedicine programs and tele-education networks to connect remote communities with clinical expertise and educational resources. These innovations have made Memorial an early and enduring leader in combining rural training with technology-enabled education and care.

2.2. Included studies

The synthesis included five studies conducted as part of a coordinated research program by members of the research team (Table 1). These studies employ complementary methodological approaches to examine XR development, evaluation, and implementation in healthcare education.

Table 1. Programmatic Research Studies.

Study	Purpose	Design	Participants	XR Modality	Data Collection	Key Focus
Curran et al. (2022)	Explore healthcare providers' experiences with 360° VR for resuscitation training	Qualitative phenomenological study	Physicians, nurses, respiratory therapists (N=36)	360° VR video	Focus groups, interviews	User experience and perceived educational value
Aydin et al. (2025a)	Develop VR simulation for neonatal resuscitation training	Development study	Healthcare providers and learners	Virtual Reality (VR)	Usability testing, questionnaires	Simulation design and development
Aydin et al. (2025b)	Compare VR simulation and 360° video for training outcomes	Randomized crossover study	NRP providers (N=30)	VR and 360° video	Pre/post tests, surveys, performance assessment	Learning outcomes and confidence

Study	Purpose	Design	Participants	XR Modality	Data Collection	Key Focus
Attia et al. (2025)	Develop mixed reality simulation for neonatal resuscitation	Development study	Healthcare providers and learners	Mixed Reality (MR)	Usability testing, observational feedback	Simulation development and feasibility
Curran et al. (2026)	Examine adoption of XR in rural medical education	Interpretive descriptive case study	Rural healthcare providers (N=21)	VR, MR, 360° video	Interviews, thematic analysis	Implementation and adoption

2.3. Participants, data sources and synthesis approach

Across studies, participants included physicians, nurses, respiratory therapists, and allied health professionals. Data sources comprised interviews, focus groups, surveys, pre- and post-tests, performance assessments, and observational data collected from simulation labs, healthcare facilities, and rural teaching sites. Narrative synthesis was conducted to identify themes across studies (Popay et al., 2006).

3. Results

The programmatic research synthesis identified four main themes across the included studies: educational value and learning effectiveness; immersion and experiential learning; enhanced access to training and rural education benefits; and implementation considerations and limitations.

3.1. Educational value and learning effectiveness

Across studies, XR technologies were consistently seen as valuable educational tools. In a randomized crossover study comparing VR simulation and 360° video, both methods received positive feedback; however, VR simulation led to significantly higher perceived usefulness, greater confidence in neonatal resuscitation skills, and better performance on positive-pressure ventilation (PPV) tasks. Participants who experienced VR showed improved mask placement and newborn response evaluation, with blinded assessments indicating notably better PPV performance after VR training (Aydin et al., 2025b). Likewise, the VR simulation development study reported that participants found the VR environment helpful for learning and skill development, emphasizing its safety, interactivity, and realism. Participants highlighted the benefits of hands-on learning and opportunities for repeated practice (Aydin et al., 2025a). The mixed reality (MR) development study also identified the potential for XR technologies to improve skill acquisition and retention through immersive, interactive learning environments that enable healthcare providers to practice neonatal resuscitation procedures safely and repeatedly, while allowing for tactile feedback (Attia et al., 2025).

3.2. Immersion and experiential learning

A consistent finding across studies is the importance of immersion and experiential learning. Participants in the phenomenological study of 360° VR videos reported enhanced immersion, a strong sense of presence, and increased learner engagement when using VR headsets. Participants also noted that XR technologies created realistic learning environments that supported experiential learning (Curran et al., 2022). Likewise, participants in the comparative XR study reported a significantly greater sense of presence in VR simulations than in 360° videos, reinforcing the value of interactivity and immersion in XR-based learning environments (Aydin et al., 2025b). Development studies further highlighted the immersive nature of XR simulations, observing that interactive environments and realistic clinical scenarios boosted learner engagement and facilitated experiential learning (Attia et al., 2025; Aydin et al., 2025a).

3.3. Access to training and rural education benefits

The interpretive descriptive case study of rural healthcare settings identified enhanced access to training as a key advantage of XR technologies. Participants noted that XR reduced travel needs, improved access to simulation training, and supported self-directed learning in rural and dispersed environments. XR technologies were seen as especially beneficial for high-acuity, low-occurrence (HALO) clinical scenarios and refresher training (Curran et al., 2026). Similarly, the phenomenological study found that 360° VR video provided a portable, standardized way to deliver training across different locations, supporting rural healthcare education and distributed learning (Curran et al., 2022). Across the studies, XR technologies were regarded as complementary to traditional simulation-based education and as useful tools for expanding access to CPD and refresher courses.

3.4. Implementation considerations and limitations

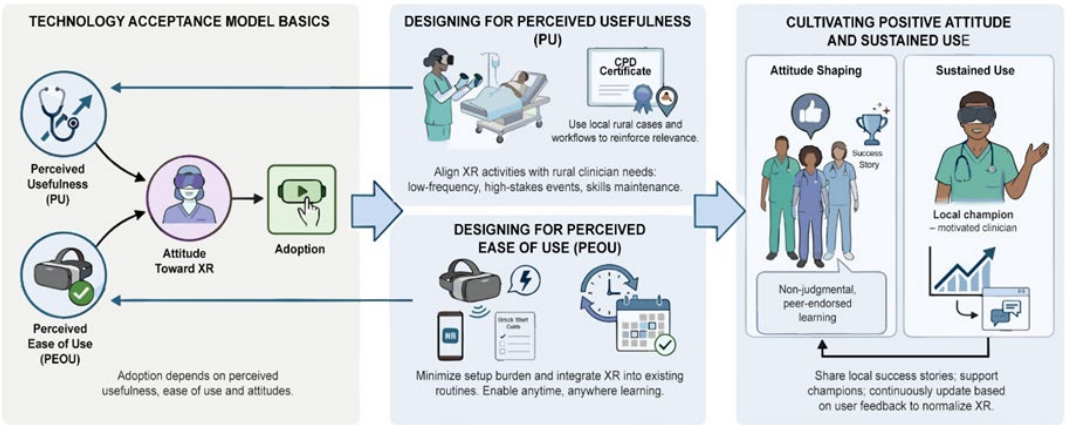
Despite the positive findings, several implementation challenges were identified across studies. Participants reported technical limitations, including hardware constraints, vision and usability challenges, and the need for improved realism and interactivity (Aydin et al., 2025a). In rural settings, participants also identified issues related to technical support, costs, and infrastructure requirements. Additionally, the lack of tactile feedback and the learning curves associated with XR technologies were noted as potential barriers to implementation (Curran et al., 2026). Participants in the phenomenological study suggested enhancements in video quality, interactivity, and realism, further highlighting areas for future development (Curran et al., 2022).

4. Discussion and conclusions

Several limitations should be considered when interpreting these findings. First, studies included in this synthesis were conducted within a single research program and geographic region, which may restrict their generalizability. Some of the studies also focused on early-stage development and implementation of XR technologies, and long-term educational outcomes were not assessed. Variations in study designs and participant groups may also hinder direct comparisons across studies. Nonetheless, the findings from this synthesis suggest that XR technologies hold significant potential to improve healthcare education, especially in rural and remote settings. Future research should explore long-term learning outcomes, cost-effectiveness, and implementation strategies across diverse healthcare environments. Additionally, further investigation of multimodal XR approaches may offer insights into enhancing educational design.

An important aspect of introducing new educational technology systems is assessing the feasibility of end users adopting and using them. Curran et al. (2026) used the Technology Acceptance Model (TAM) (Davis, 1989) to explore factors affecting the adoption and usage of XR technologies in rural medical education. TAM suggests that technology adoption mainly depends on two key factors: perceived usefulness (PU) and perceived ease of use (PEOU). PU is the degree to which users believe technology will be useful for staying current in their skills. In this study, rural healthcare providers saw XR as helpful for increasing access to training, supporting preparation for HALO events, creating immersive and experiential learning opportunities, and enabling repeatable, self-directed education. PEOU refers to how easy it is to learn and use technology. Factors that affected ease of use included technical reliability, availability of IT support, usability, hardware setup, and user familiarity with XR systems. Participants also identified barriers, such as technical complexity, limited infrastructure, and steep learning curves that could hinder adoption. Figure 1 presents a conceptual framework based on the TAM to support the adoption and sustained use of XR in rural healthcare education. The left panel illustrates core TAM constructs, showing that PU and PEOU influence clinicians' attitudes toward XR, which in turn drives adoption. The middle panel outlines strategies to enhance PU and PEOU. PU is strengthened by aligning XR activities with rural clinical needs, using local cases, and supporting CPD for HALO events. PEOU is promoted by minimizing setup burden, integrating XR into existing workflows, and enabling flexible, accessible learning. The right panel highlights factors that cultivate positive attitudes and sustained use, including peer-endorsed learning, success stories, local champions, and continuous feedback. Together, these elements create a cycle that supports adoption, reinforces positive attitudes, and promotes long-term integration of XR in rural clinical education.

Figure 1. Adoption of Extended Reality (XR) in Rural Medical Education: A Technology Acceptance Model (TAM) Approach (Curran et al., 2026).



Overall, this programmatic research synthesis demonstrates that XR technologies offer promising opportunities to enhance SBME, improve access to training, and support experiential learning in rural healthcare settings. While implementation challenges remain, XR technologies represent an emerging and valuable approach to supporting healthcare education and CPD.

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DESIGNING A TEACHER DEVELOPMENT MOOC CAMP TO PROMOTE ANTI-RACIST EDUCATION

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Abstract

In Brazil, there are at least two laws that prescribe the teaching of Afro-Brazilians' and Brazilian Indigenous peoples' cultures and histories at schools: law 10.639/03 and law 11.645/08. However, although these laws are about 20 years old, they have not been thoroughly implemented yet. Studies (Dias, 2024; Figueiredo, 2025) have pointed out that one of the reasons for this failure has been the fact that teachers do not feel well-prepared to implement them. While some of these teachers mention that they do not know how to adapt the curriculum, others not even know or understand exactly what the laws are about. Therefore, this participatory action research (Kemmis & Wilkinson, 2011; Cardoso, 2023) aims at finding effective ways of implementing these laws. The idea is not simply to prescribe activities, but to understand collaboratively what could be done to minimize the problem. To do so, we have been developing a series of activities, including a MOOC camp, which consists of an on-line course with weekly sessions for discussion (Cardoso, 2021, 2022), to be used for sharing readings and videos about the topic and as a kind of repository of materials developed during the two-month camp. This MOOC camp is being prepared by a group of graduate and post-graduate students who are (future) language teachers. The on-line course is divided in six modules based on the series of lectures *Towards an Anti-Racist Basic Education,* which were organized by our research group in 2023. The theoretical framework of the research includes discussion on anti-racist education (Cavaleiro, 2001), Critical Racial Literacy (Ferreira, 2015, 2017) Critical Applied Linguistics (Pennycook, 2021; Pennycook; Makoni, 2020; Rajagopalan, 2003; Silva; Pereira, 2022) and critical-reflective teacher development (Cardoso, 2024, Celani, 2002; Freire, 1998/1996; Liberali, 2015; Liberali; Carrijo, 2024). As it is a long-term ongoing study, there are no final results, but project assessment is constant and some of the findings will be discussed during the oral presentation.

Keywords: *Anti-racist education, critical racial literacy, critical-reflective teacher development, MOOC camps.*

1. Introduction

This study is part of a bigger research project called CEALD (Collaboration, Learning Strategies and Digital Literacy), which has as one of its main aims the development of critical and reflective language teachers. In this cycle of the research, we focus on the promoting a more decolonial and anti-racist language education.

In Brazil, slavery was abolished in 1888. However, still today black people and indigenous people are discriminated against and suffer prejudice. Although the black population comprises more than half of the population (55,5%) (Brazilian Census, 2022), we are still treated as a minority and in many ways marginalized. This fact is the result of the coloniality in which we still live, but which we are trying to combat. One way of promoting this decolonial turn (Maldonato-Torres, 2023) is through education.

There are at least two Brazilian laws that prescribe the teaching of Afro-Brazilians' and Brazilian Indigenous peoples' cultures and histories at schools: law 10.639/03 (Brasil, 2003) and law 11.645/08 (Brasil, 2008). However, although these laws are about 20 years old, they have not been thoroughly implemented yet. Studies (Dias, 2024; Figueiredo, 2025) have pointed out that one of the reasons for this failure has been the fact that teachers do not feel well-prepared to implement them. While some of these teachers mention that they do not know how to adapt the curriculum, others do not even know or understand exactly what the laws are about.

For the development of a decolonial and anti-racist linguistic education, we understand that it is not enough to know that these laws exist; we need to collaboratively think about ways to implement them in all segments of Basic Education, as well as in all subjects of the school curriculum, including the Portuguese language and additional languages (Figueiredo, 2025; Cardoso, 2024).

Therefore, the main objectives of this specific study are the following: (a) to find effective ways of implementing the laws 10.639/03 and 11.645/08 and (b) to understand collaboratively what could be done to minimize the problem.

2. Theoretical background

This study may be situated in what is called Critical Applied Linguistics (Pennycook, 2021; Pennycook; Makoni, 2020; Rajagopalan, 2003; Silva; Pereira, 2022;) since, as mentioned by Pennycook; Makoni (2020, p. 13), it "makes a case for a greater role of local forms of knowledge about languages, their use, their social and cultural roles, their place in education". We believe in an "applied linguistics that can embrace Global South perspectives needs researchers who are culturally grounded, political engaged, continuously self-reflexive, and capable of adopting dialectic and multiple perspectives on data" (Pennycook; Makoni (2020, p. 12).

Besides the Critical Applied Linguistics, its theoretical framework of the research includes discussion on other different concepts, such as decoloniality, anti-racist education, critical racial literacy and critical-reflective teacher development.

Although the space here is limited to discuss all these concepts, I would like to briefly present two of them that are essential to this study. One is the "Anti-racist Education", proposed by Eliane Cavaleiro (2001/2024) and the other is "Critical Racial Literacy", coined by Aparecida de Jesus Ferreira (2015, 2017).

Cavaleiro (2001/2024, p. 128-129) presents as the main characteristics of an Anti-racist Education the following:

> 1. Acknowledges the existence of racial problems in Brazilian society.
> 2. Constantly seeks reflection on racism and its derivatives in daily school life.
> 3. Rejects any prejudiced and discriminatory attitude in society and in the school environment, and ensures that interpersonal relationships between adults and children, black and white people, are respectful.
> 4. Does not disregard the diversity present in the school environment: uses it to promote equality, encouraging the participation of all students.
> 5. Teaches children and adolescents a critical history of the different groups that constitute Brazilian history.
> 6. Seeks materials that contribute to the elimination of Eurocentrism from school curricula and address racial diversity, as well as the study of black issues.
> 7. Considers ways and means of educating for the positive recognition of racial diversity.
> 8. Develops actions that enable the strengthening of the self-concept of students belonging to discriminated groups.

Based on Cavaleiro's studies and the Critical Race Theory (Gillborn, 1995), Ferreira (2015) proposes to educators the development of Critical Racial Literacy, that she understands as:

> Critical racial literacy is about reflecting on race and racism, and it allows us to see our own understanding of how race and racism are treated in our daily lives, and how much race and racism impact our social identities and our lives, whether at work, in the school or university environment, in our families, or in our social relationships (Ferreira, 2015, p. 318).

The intervention activities used in the study are developed aiming at the development an anti-racist education and for the narrative interviews/research will be based on Ferreira's Critical Racial Literacy, as we will use autobiographies to reflect on live experiences of racism and how to deal with them.

3. Research methodology

As mentioned before, this participatory action research (Kemmis & Wilkinson, 2011; Cardoso, 2024) aims at finding effective ways of implementing these laws. The idea is not simply to prescribe activities, but to understand collaboratively what could be done to minimize the problem.

To do so, we have been developing a series of activities, including a MOOC camp, which consists of an on-line course with weekly sessions for discussion (Cardoso, 2021, 2022), to be used for sharing readings and videos about the topic and as a kind of repository of materials developed during the seven-week camp.

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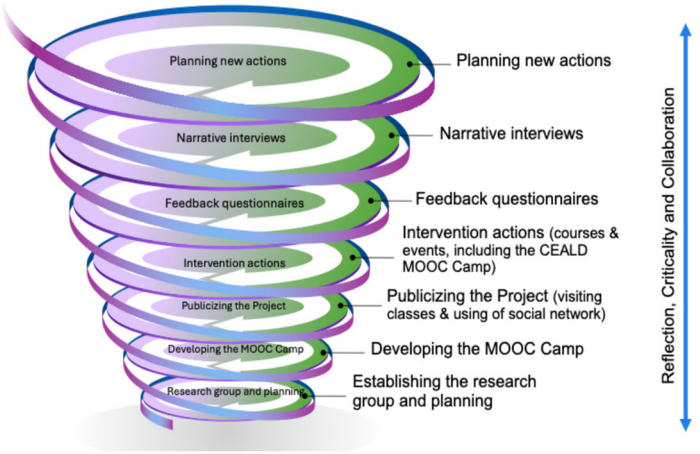
The MOOC Camp is part of a bigger Participatory Action Research and Narrative Research, which will be used to consider the impact of the development and implementation of the

3.1. Participatory action research

We consider this study a Participatory Action Research Project because the reflexive process begins during the teaching practice itself. Besides, we seek social transformation by inviting other (future) teachers to think with us, participating in narrative interviews, conversations, or outreach activities such as events, lectures, courses, or by creating reflective journals. It is a type of study where there is often no distinction between subjects and researchers, as we are all participants of the research.

To represent the different phases of the study, instead of using the common single action research cycle (planning => action & observation => reflection => new plan), we prefer to use an elliptical series of reflective cycles (Fig. 1) because we never come to the same point.

Figure 1. Reflective Cycles of the Participatory Action Research.



Source: Adapted from Cardoso (2023, p. 39)

As shown in the picture, reflection, criticality and collaboration are present during the whole process. Kemmis & Wilkinson (2011, p. 41-43) describes the participatory action research as social, participative, practical and collaborative, emancipatory, critical and recursive (reflexive and dialectical).

For this study we will concentrate on the cycle Developing the MOOC Camp. The main phases of this part of the research are the following: (1) establishing research group and planning; (2) editing the videos and searching for reading texts; (3) structuring each module and preparing activities; (4) put the modules together and assess the final product; (4) register the course; (5) promoting and implementing the pilot course; (6) first narrative interviews.

During the whole process, participants will be encouraged to use a research diary to take notes of aspects they find interesting in relation to the project.

3.2. Narrative interviews

Besides the research diary, another research technique to be used are autobiographical narratives, instead of a formal interview, based on Ferreira (2015, 2017), the idea is to use a set of reflective questions to let participants narrate episodes of racism and to think of ways to develop a more anti-racist language education.

In one of his books, Ferreira (2017) presents three reflective questions before each chapter of the book:

(1) What do you understand by anti-racist education?
(2) What does anti-racist education have to do with language teacher training?
(3) How can anti-racist education contribute to language teacher training/development?

We would like to use these questions during the preparation of the MOOC Camp and later with the participants of pilot course. But before then, another question would be used. It is from Ferreira (2015, p. 53):

(4) How did you become aware that racism exists? How did you realize that racism exists?

Other possible questions to be asked would be:

(5) Do you remember how many black professors you had(have) at the university? Did(Do) you identify with them? Why(not)?

We are also considering the possibility of using images as prompts for the construction of these autobiographies.

3.3. Research participants and the MOOC camp

The MOOC camp is being prepared by a group of post-graduate students who are language teachers, but also by some undergraduate students (future teachers) and other professors. Right now, we are about fourteen people involved in the process. At least two people will be responsible for each module. But before that, we are watching all the videos of the lectures, and we will meet by the end of March to organize the pairs or trios and choose the corresponding module.

Some of these participants will be invited for the narrative interviews and we will also invite teachers who will participate in the pilot MOOC. The idea is to reflect on the process during the whole time: development of the course, while piloting and after the first group. Parallel to the development and implementation of the MOOC Camp, our idea is to organize events, including a second cycle of lectures, produce articles and organize at least one book about the topic.

The MOOC will consist of seven modules: an introductory one; and six which will correspond to each lecture of the 2023 event: Critical Racial Literacy; Indigenous People Bilingual Education; *Pretuguês* (Black *Português*); Original People Literature; Black and Indigenous Brazilian Important Professionals (who be celebrities, but are still unknown by most of us); How to implement the laws 10.639/03 and 11.645/08.

4. Expected results

As it is an ongoing research project, there are no final results yet, but we expect that with this study to contribute to develop initial and ongoing training of more critical-reflective language teachers, through the sharing of knowledge and experiences, participation in research, and collaborative production in publications. We also expect to promote appreciation of the languages, literatures, and other cultural aspects of the African, Afro-Brazilian and Indigenous peoples, and an understanding that Brazil is not a monolingual country. In other words, we expect to transform some colonial beliefs into decolonial ones (Fonseca, 2024), while contributing to the elimination of linguistic and non-linguistic prejudices.

5. Conclusions

Being part of the group which is planning the MOOC is also formative. Watching videos, choosing which part(s) of these videos to be used in the course and searching for adequate reading passage(s) for each module make us already reflect on our own practice. We consider what we have done so far and what can be done in the future to develop more social aware anti-racist learners and teachers. At the same time, collaboratively designing activities is a good way of understanding importance of promoting this kind of activity (project work) with our own learners.

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MANAGING RELIGIOUS DIVERSITY IN PRIMARY SCHOOLS: EDUCATORS' PERSPECTIVES ON INCLUSION, BELONGING AND SCHOOL CLIMATE

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Abstract

School climate and students' sense of belonging play a central role in educational inclusion, particularly in culturally and religiously diverse contexts. This qualitative study examines how educators in Greek primary schools perceive and manage religious diversity, with a focus on the inclusion of Muslim pupils. Drawing on interviews with teachers, school principals, and religious instructors in the region of Thrace, the study explores everyday practices, challenges, and coping strategies related to religious education and school rituals. Findings reveal considerable variation in how schools organize exemption procedures, learning activities, and participation in religious events, often depending on local decision-making rather than unified guidelines. Educators express concern that inconsistent practices may unintentionally affect pupils' emotional security and sense of belonging. At the same time, many participants describe deliberate efforts to promote respectful dialogue, inclusive classroom climates, and positive peer relationships. The study highlights the psychological dimensions of inclusion, emphasizing how organizational clarity, professional confidence, and supportive school leadership contribute to a climate where diversity is managed constructively. Implications are discussed in relation to inclusive school environments and educator support.

Keywords: *Educational inclusion, religious diversity, school climate, sense of belonging, primary education.*

1. Introduction

The research literature consistently shows that students' school experiences are shaped not only by the curriculum, but also by the quality of relationships, the sense of safety, and the extent to which schools communicate that students are legitimate members of the community. From this perspective, school climate does not merely refer to the "atmosphere" of an institution, but to the broader constellation of relationships, norms, and practices that influence students' participation, learning, and well-being. Similarly, school belonging is understood as the experience of being accepted, recognized, and supported within the educational environment, and research has shown that teacher support is among the strongest predictors of this sense of belonging (Osterman, 2000; Thapa et al., 2013). Likewise, Allen and colleagues (2018) demonstrate that supportive relationships and well-organized school processes significantly shape students' sense of belonging.

These issues become particularly salient in schools where religious differences are visible in everyday life. In European debates on education about religions and beliefs, emphasis has gradually shifted from strictly confessional approaches toward interpretive, dialogical, and inclusive models capable of fostering mutual understanding and social cohesion (Jackson, 2016). In Greece, this discussion carries particular significance, as the teaching of Religion remains closely tied to ongoing debates concerning the role of Orthodoxy, exemption procedures, and the ways in which public schools respond to religious pluralism (Koukounaras Liagkis, 2015; Markoviti, 2019). In Western Thrace, where there is a historically significant presence of the Muslim minority, education has long been recognized as a sensitive arena situated at the intersection of identity, educational policy, and intercommunal relations (Dragonas & Frangoudaki, 2006).

The present article examines the religious inclusion of Muslim primary school students in Thrace through the lens of teachers' practices and representations regarding the management of religious diversity within the school environment. The analysis is structured around three dimensions particularly relevant to

the theme of the conference: the organizational management of diversity, everyday classroom practices, and the institutional conditions that may either support or undermine inclusive processes. Within this framework, the central research question concerns how educators understand and manage religious diversity in ways that intentionally or unintentionally contribute to strengthening, complicating, or diminishing Muslim students' sense of belonging and the overall school climate.

2. Methodology

2.1. Participants

The study used a purposive sampling strategy to reflect the professional and institutional diversity of primary schools in Thrace, Greece. The sample size was established according to the principle of theoretical saturation and included 30 participants from four professional groups relevant to the study: 10 general primary teachers (PE70) working in public schools attended by pupils from different religious backgrounds; 6 Islamic religion teachers involved in Muslim religious education programmes; 7 PE73 teachers working in minority schools attended by Muslim pupils; and 7 principals or deputy principals from schools characterized by religious diversity.

Participants came from all three administrative areas of Thrace. They were selected from a total of 206 primary schools (107 public and 99 minority schools), allowing the study to include a broad geographical, institutional, and demographic range. Selection criteria included professional experience, willingness to reflect on practice, years of service, and employment status. The group of Islamic religion teachers was particularly important because many of them worked across several schools and religious institutions, offering both educational and community perspectives.

2.2. Instrument

Data was collected through semi-structured interviews, which are suitable for exploring sensitive and complex topics such as religion, identity, and school inclusion, as they allow participants to describe their experiences in depth within a flexible format (Creswell & Poth, 2018).

The interview guide was developed through an iterative process that included a review of the literature on religious diversity, intercultural competence, and minority inclusion, consultation of educational policies, and analysis of similar existing tools. The final guide included four main thematic areas: (a) curriculum and teaching practices; (b) perceptions of religious inclusion; (c) institutional policies and practices; and (d) professional experiences and training needs related to religious diversity.

To ensure cultural sensitivity and neutral wording, the questions were written in inclusive language and reviewed by two specialists in intercultural education and social psychology. The guide was then adapted for each participant group while maintaining the same overall themes. Before the main data collection, a pilot study was conducted with four respondents, one from each group, to test the clarity and relevance of the questions.

2.3. Data collection procedure

Interviews were conducted both face-to-face and online, depending on participants' availability and local conditions. Before each interview, participants were informed about the aim of the study, the use of the data, and their rights regarding confidentiality and personal data protection. Informed consent was obtained in written or digital form.

Most participants did not agree to audio recording. Therefore, data were collected through detailed notes taken during the interviews. At the end of each discussion, the main ideas were reviewed with participants and confirmed by them. All data were anonymized, and each participant received a generic code such as "Subject X," without identifying the school or professional role.

A total of 30 semi-structured interviews were conducted in public and minority schools reflecting the local religious diversity, including Orthodox Christians, Turkish-speaking Muslims, Pomaks, and Roma communities. Interview length was adapted to the context, averaging around 15 minutes for face-to-face interviews and slightly longer online to allow for additional procedural details. Open-ended questions encouraged participants to share their experiences, while researchers intervened only to clarify responses and support free expression.

2.4. Data analysis strategy

The data were analyzed using thematic analysis, following the approach proposed by Braun and Clarke (2006), which is widely used in qualitative research to identify and interpret patterns of meaning in textual data. The analysis followed six stages: familiarization with the data, initial coding, theme development, theme review, theme definition and naming, and final interpretation.

The analysis focused both on recurring themes and on the specific perspectives of participants, allowing the identification of similarities and differences across the four professional groups. The credibility of the findings was strengthened through triangulation of perspectives from the different respondent groups and through the use of researchers' reflexive journals, which helped reduce interpretive bias.

3. Results

A comparative analysis of the perspectives of the four professional groups revealed both important similarities and relevant differences in the ways religious diversity is managed in primary schools in Thrace. The findings are presented across four main dimensions: organizational management of religious diversity, everyday pedagogical practices and student engagement, institutional conditions of inclusion, and broader attitudes toward inclusion and areas for improvement.

3.1. Organizational management of religious diversity

A first important finding concerns the lack of consistency in the implementation of administrative procedures related to the exemption of Muslim pupils from Religious Education classes and their participation in Christian religious activities. Participants reported the existence of formal procedures; however, their practical application differed across schools, and the level of institutional clarity varied. One teacher described the standard process as follows: "Parents complete the form in September, we draft the minutes and record it in myschool" (Subject 4). Other participants, however, referred to uncertainty regarding decision-making procedures and the role of exempted pupils during religious activities.

Beyond formal documentation, Muslim pupils were included through different local arrangements: remaining in class with alternative tasks, arriving later at school, or attending certain events without active participation. One teacher explained: "During church attendance, Muslim students stay at school with a teacher and do art activities" (Subject 2). These differences suggest that the status of exempted pupils is not regulated through a common framework, but negotiated at the level of each individual school.

A second organizational issue concerned delays in the appointment of Islamic religion teachers. Both teachers and school leaders viewed their presence positively, but reported that administrative delays affected the continuity of religious instruction and timetable organization. As one principal noted: "The Imam arrived in January, which disrupted the timetable and delayed Religious Education" (Subject 3). As a result, some schools relied on temporary and improvised solutions, increasing organizational pressure and reinforcing the fragile nature of the educational response offered to Muslim pupils.

3.2. Everyday pedagogical practices and student engagement

Across all participant groups, there was a clear orientation toward teaching methods aimed at encouraging active student participation and creating an inclusive classroom climate. Teachers described the use of interactive, interdisciplinary, and reflective approaches such as storytelling, guided discussion, role-play, thematic projects, drawing, and collaborative activities. Although the emphasis varied across professional categories, there was broad agreement that religious diversity is easier to manage when students are actively involved and lessons are based on dialogue and reflection.

PE70 teachers mainly emphasized interdisciplinary approaches and the use of historical or civic content in Religious Education. Islamic religion teachers combined traditional methods with modern participatory strategies, while PE73 teachers more frequently described activities based on questioning, text analysis, and moral reflection. One PE73 teacher stated: "I ask questions so students develop critical thinking" (Subject 6).

Participants also agreed that student engagement increased when lessons involved creativity, personal expression, and collaboration. At the same time, they identified recurring challenges, including different levels of student interest, language barriers, difficulties in understanding religious texts, and the lack of age-appropriate materials. Assessment was described mainly as formative and continuous, based on oral questions, observation, practical exercises, and interactive tools. Summative testing appeared less important, with greater emphasis placed on participation, reflection, and understanding.

3.3. Institutional conditions of inclusion

The analysis also revealed structural constraints affecting the coherence of religious education in multicultural settings. Islamic religion teachers frequently reported a lack of official resources, the absence of a common curriculum, and the need to create their own teaching materials. One participant expressed this directly: "There are no official textbooks for teaching Islam, so we all have to make our own materials" (Subject Y23). Similarly, PE73 teachers referred to outdated textbooks, language comprehension difficulties, and insufficient materials for younger pupils.

Another major issue concerned the limited professional integration of Islamic religion teachers within the school community. Participants described forms of institutional marginalization, including restricted participation in decision-making processes and incomplete professional recognition. One teacher noted: "We aren't part of the Teachers' Council, and that makes us feel marginalized" (Subject Y28). This peripheral position affects not only teachers' professional status, but also the consistency of support provided to Muslim pupils.

School leaders also highlighted the lack of a coherent institutional framework and the need for clearer guidance regarding the status of exempted pupils and their participation in religious activities. Overall, the data suggest that religious inclusion depends not only on teachers' goodwill, but also on the existence of institutional structures that support coherent, predictable, and fair practices.

3.4. Cross-cutting dimensions: Attitudes toward inclusion and directions for improvement

Despite these structural difficulties, most participants expressed positive attitudes toward religious inclusion. Across all four groups, there was a shared view that Religious Education should promote mutual respect, empathy, freedom of conscience, and dialogue among pupils. Teachers tended to associate the subject with the transmission of universal values and the creation of opportunities for mutual understanding, rather than the promotion of a single confessional perspective. One participant summarized this view as follows: "All students can gain something from Religious Studies—whether knowledge or experiences that foster skills like acceptance, inclusion, and tolerance of diversity" (Subject 12).

Participants also offered similar recommendations for improving current practices. The most common suggestions included clarifying exemption procedures and participation in school rituals, updating teaching materials, strengthening professional training, and introducing comparative or dialogical approaches to Religious Education. One principal proposed that: "A single comparative religion course would solve many problems and reduce exemptions" (Subject 18). Participants also stressed the importance of collaboration with parents and the wider community so that religious inclusion does not remain the sole responsibility of individual teachers.

Overall, the findings indicate that there is a positive attitudinal basis for inclusion; however, this is weakened by limited institutional coherence and insufficient resources. Inclusive practices do exist, but they often depend on local initiative and the personal commitment of educational actors rather than on a strong systemic framework.

4. Discussion

The central finding is that religious inclusion should be understood as a process of building school climate and belonging, not merely procedural compliance. Muslim pupils' experiences are shaped by ordinary moments, who joins morning prayer, where exempted pupils wait, what alternative activities they receive, that carry psychological significance by signalling legitimacy and equal status (Allen et al., 2018; Osterman, 2000). Building on this, the study introduces the concept of the Exemption Paradox: exemption procedures intended to protect freedom of conscience may unintentionally signal symbolic peripherality when pupils are managed through improvised arrangements or spatial separation. The result is a tension between legal accommodation and psychological belonging, students may be formally enrolled while experiencing everyday signals of secondary membership (Yuval-Davis, 2006).

Two implications follow. First, organizational coherence matters for belonging: schools with clearer rules produce more stable experiences, while ad hoc solutions lead pupils to perceive their place as conditional or peripheral. In the Greek context, where debates on Religious Education and exemptions remain sensitive, the quality of local decision-making directly shapes students' lived experiences (Markoviti, 2019). Second, the data reveal a distinction between relational inclusion - teachers' sensitivity, dialogical methods, avoidance of stigma (Jackson, 2016) and institutional inclusion. Positive interpersonal relations are necessary but not sufficient: a school may be relationally inclusive while remaining institutionally fragile. Inclusion also requires adequate resources; participants noted persistent structural gaps including absent textbooks for Islamic religion, lack of a common curriculum, and outdated materials, all of which constrain engagement regardless of teacher goodwill (Aseery, 2024; Koukounaras Liagkis, 2022).

The professional status of Islamic religion teachers and the role of school leadership are equally significant. Teachers who reported delayed appointments and exclusion from decision-making processes carry symbolic weight: when educators serving a minority group are institutionally marginalized, pupils implicitly receive a message about the value placed on their needs (Dragonas & Frangoudaki, 2006). School principals mediate between policy ambiguity and everyday practice, but leadership alone cannot compensate for absent systemic guidance (Thapa et al., 2013). More broadly, this study shifts attention from narrow debates about exemptions toward the quality of the school environment as a whole, showing

that belonging is produced through the practical organization of everyday school life — not curriculum content alone.

5. Conclusions, practical implications, limitations and future research

The study shows that religious inclusion in primary schools emerges not from individual teacher goodwill alone, but from the convergence of predictable rules, inclusive leadership, adequate resources, and diversity-sensitive pedagogy. Muslim pupils' sense of belonging depends on the everyday institutional signals that their presence is legitimate, recognized, and equal. Four practical improvements follow: (1) clearer and consistent exemption procedures and rules for participation in school rituals; (2) alternative activities with genuine educational value for exempted pupils; (3) timely appointment and full professional recognition of Islamic religion teachers; and (4) updated resources and continuous professional development to help teachers address religious differences constructively. Three limitations should be noted: the study captures adult rather than pupil or family perspectives; the absence of audio recording in most interviews restricted verbatim data, though participant validation of notes supported credibility; and the socio-cultural specificity of Thrace limits transferability. Future research should incorporate pupil and parent perspectives, comparative designs across regions or school types, and longitudinal studies tracking how policy changes shape everyday school practices.

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TOUCHING THE SOIL, CULTIVATING A COMMON HOME: A LIVED EXPERIMENT IN REGENERATIVE EDUCATION

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Abstract

This proposal recounts the experience of establishing a volunteer-led community garden founded in April 2023 on a university campus in Madeira. Born from a felt need by a diverse group of students and teachers, our aim was to find a physical home for a learning community dedicated to ecological and social issues. The objective is to explore how the campus space can function as a collaborative "third space" that nurtures regenerative agriculture, interdisciplinary exchange, and social cohesion through shared experience. In our weekly co-creation sessions, we meet as a mixed group of students, teachers, and neighbors to navigate a fluid process of learning together. We embrace a horizontal dynamic where research occurs through experiments, failures, and the repetitive act of returning to the same soil every week. Activities range from artistic workshops and practical tasks to the conscious decision to deconstruct the pressure to produce: the garden is a place to work, but also to rest, do nothing, and simply observe. By physically creating this Common Space, we observe the dynamics between environmental care and our own well-being, transforming the garden into a tool for ubiquitous and continuous learning. Reflecting on our shared experience as volunteers, one of our most vital findings is the value of rest and connection. We experience the garden as a safe space where the pressure to constantly produce is replaced by a culture of mutual care. We observe that "getting our hands dirty" facilitates conversations that rarely happen in seminar rooms, as shared manual tasks lower social barriers. Furthermore, the process of regenerating the land and the permission to make mistakes fosters a tangible sense of belonging and purpose. Transversal skills such as observation, patience, problem-solving, and interdisciplinary teamwork are thus cultivated alongside flowers, aromatic herbs and vegetables. With this project, we explore the idea that pedagogic quality does not always require high-tech tools; sometimes, it requires a hoe and compost. Through this lived practice, we embody principles of regenerative education, cultivating sustainability rooted in shared responsibility for our common environment. Ultimately, the garden is not merely an aesthetic choice or a leisure activity, but a supportive instrument for sustainable developments in education, positioning itself as an infrastructure for a resilient, interdisciplinary, and healthy shared future.

Keywords: *Community garden, learning community, regenerative practice, public space, salutogenic design.*

1. Introduction

This paper recounts and reflects on the experience of being part of a community garden, Mãos na Terra (MNT). MNT is a project born of a collective and organic effort, involving the people who have gradually become part of it, each bringing their own perspectives, ideas, and suggestions. Although it originated within a university that supports and backs it, this experience is not an institutional educational program. Instead, it is a space open to both the academic and non-academic community, and open to anyone who wishes to participate, regardless of age or background. It functions as a meeting place, a public space, as well as a shared, free of charge, environment for lifelong learning.

Situated on the island of Madeira, our community is embedded in a landscape shaped by more than six hundred years of resource extraction, from the historical sugar revolutions (Moore, 2009) to the contemporary pressures of overtourism. Today, the ecological precarity of this environment is acutely visible through intensifying cycles of fires and floods. This trajectory has established a profound metabolic rift (Foster, 1999) where societal demands often operate in contradiction to the biological limits of the earth. These limits are particularly tangible on an island (Borgnino, 2022). In the contemporary context, we observe a painful paradox: while the island is marketed globally as a pristine sanctuary where tourists go to rest, residents are increasingly subjected to demands for high-speed efficiency and constant production.

These systemic pressures manifest through a severe housing crisis and growing social isolation. As land prices skyrocket and rural areas depopulate, more and more residents are losing access to the earth. These challenges the boundaries of the island while reaching the limits of human resilience.

Within the university environment, we observe that the exhaustion of the landscape is directly mirrored in the faces of our community. The soil erosion on the steep ravines and the failing crops in local fields serve as biological mirrors for the systemic fatigue experienced within performance-driven educational systems. The metabolic rift in the earth is directly entangled with the physical exhaustion of our own bodies. This condition is a symptom of a systemic imbalance: a perspective that demands infinite growth from both finite soils and finite human nervous systems. When students, neighbors, or teachers experience burnout, or when a harvest fails, we learn to see that these are not personal failures. They are interconnected symptoms of environmental degradation and a cycle of extractive productivity operating at industrial speeds. Recognizing this collective exhaustion reinforces our need to physically come back down to earth, finding a grounded orientation in the soil itself (Latour, 2018). Because human fatigue and ecological collapse are rooted in the same mindset, we recognize that they must be addressed together.

In April 2023, the community garden Mãos na Terra emerged as an initiative rooted within the university. We recognized a shared desire among students, teachers, and neighbors to establish a physical home for a learning community (hooks, 2003) focused on ecological inquiry and well-being. The project was founded to create a space where environmental questions could be explored deeply, while simultaneously providing a sanctuary for rest and mental health. Through our ongoing work, the garden has become an environment for our own lived experiments in human connection and ecological care. By opening this porous common space, we sought to build a bridge between the university campus and the neighborhood. This experiment has been characterized by mutual support between the project and the institution, allowing for a shared exploration of what it means to care for a common environment.

2. Methodology: Regenerative pedagogy and ecological mirrors

In response to the shared exhaustion across the campus, city and island, our intention was to cultivate a culture of collective care. We acknowledge that meaningful learning requires periods of stillness and observation. Through the act of planting and sitting with open questions together, we discover that the health of the community is intimately linked to the health of the soil. The physical home of our project is a previously unused corner within Quinta de São Roque, a property owned by the university situated five minutes on foot from the main campus. Until November 2025, when the construction of new student dormitories began, the grounds served as an easily accessible green space for the community. Amidst the noise and the physical reshaping of the wider grounds, our garden project continues to occupy a humble niche within this estate, functioning as a civic pedagogy space on the margins of the institution (Antaki et al., 2024). In this space, our learning community becomes a tangible "third space" where the formal boundaries of the institution soften (Sletto et al., 2024). It serves as a neutral, shared ground where international students seeking a connection to their temporary home can share tools and conversations horizontally with university staff and lifelong neighbors. We operate on a principle of equality of knowledge, observing how the deeply rooted knowledge of the territory meets diverse global perspectives in this shared soil. Building upon our physical presence in the garden, we frame our pedagogical approach through the lens of regenerative cultures (Wahl, 2016). We view agroecology (Wezel et al., 2009) not merely as a collection of agricultural techniques but as a vital social and cultural bridge. Just as companion planting creates mutually beneficial networks within the soil, our shared tasks weave together ecological awareness and cultural exchange. By shifting our focus away from the familiar demands of extractive productivity, we cultivate a practice of regenerative participation. Working closely with the natural rhythms of the seasons teaches us the art of delayed gratification. We learn that placing a seed into the earth is a profound exercise in intergenerational responsibility. Through this integrated approach, the act of tending to the garden simultaneously tends to our shared social fabric. This approach did not begin with a formal academic plan. Instead, it emerged organically from our shared physical routines in the garden, anchoring our learning directly in the local environment (Gruenewald, 2003) and acknowledging that our collective knowledge grows from practical engagement with the living world (Ingold, 2000). We are guided by what can be called the principle of ecological mirrors, allowing the physical realities of the natural world to reflect and inform our social dynamics.

As we work with the earth, we learn to recognize a necessary distinction between sustainability, restoration, and regeneration. Sustainability often seeks to maintain a current baseline, yet we observe that both our soil and our collective energy are already depleted. Restoration implies returning to a fixed point in the past, often communicating the assumption that we know exactly what nature needs. Instead, our shared practice focuses on regeneration, which requires us to actively build fresh capacity within a degraded system. We position ourselves not as commanders of the landscape but as active participants within the

more-than-human world. We find a powerful ecological mirror for this regenerative pedagogy in the practice of syntropic farming (Andrade et al., 2020). Pioneered by Ernst Götsch, this agricultural model actively replaces the logic of extraction with the logic of systemic abundance. On our island, we look to the ancient Laurissilva forest (Fernández-Palacios et al., 2017) as a local guide for these complex dynamics. In a syntropic system, diverse plant species are intentionally placed together not to compete, but to mutually support each other through continuous cooperation. Learning from this ecological dynamic also means that we are actively welcoming spontaneous plants and weeds, gently challenging the urge to strictly control the landscape. We apply this principle directly to our social structure to foster a deep sense of belonging and inclusion. By welcoming students, teachers, and neighbors to work side by side, we cultivate a human polyculture that shapes the garden into a common space. In this shared environment, living in plurality also means embracing unplanned, messy human dynamics rather than seeking a perfectly curated community. Beneath the soil, a healthy ecosystem relies on an interconnected network of roots and fungi to share water and vital nutrients. We guide our shared project through open dialogue, where collective action emerges from being deeply present together. The daily choices regarding our small corner of the estate are shaped collaboratively by those whose hands are actively in the dirt. By allowing decisions to surface organically from the collective conversation, we nurture a shared sense of responsibility that translates our shared reflections into grounded, tactile practice.

3. Lived experience: The messiness of the garden and the right to rest

Putting these regenerative principles into practice requires us to accept that our garden is not a closed, perfectly controlled environment. Our commitment to a tactile methodology is continuously tested by the shifting realities of the campus around us. For example, since November 2025, a construction site has been established on the wider grounds of the property to build new student housing. This new physical reality required us to reevaluate our presence and the frequency of our gatherings. The weekday noise and the activity on the site prompted a shift in our collective rhythm. Just as a plant might adjust its growth in response to changing conditions in its environment, we organically adapted our schedule to maintain the quality of our shared space. We transitioned our activities from weekly Friday afternoons to biweekly Sunday sessions, extending the duration of each gathering to allow for deeper observation and connection. We recognize that maintaining a sanctuary within a changing university environment is an ongoing practice that requires constant patience and a resilience built on responsive boundaries. This subtle shift helps us navigate the friction between the high speed of institutional development and the slow, observational pace of the garden (Maffei, 2014; Orr, 1996). We endeavor to find a balance between these two worlds, attempting to weave the reality of a growing university into our own practice of stillness. When we encounter unexpected disruptions, we try to take a breath and observe what happens before rushing to control the situation. We slowly learn to inhabit a space that is simultaneously a construction zone and a place of rest. We find that the true value of our project lies in this persistence of care (Krasny, 2024), where we do our best to defend a space for reflection while the world around us is in flux. This physical friction with the high-speed development around us naturally forced us to deeply reevaluate our own internal rhythms. In observing the natural cycles of the small piece of land, we recognize that constant growth is biologically impossible. Just as the physical geography of our island possesses clear and finite boundaries, our human energy has strict natural limits. We translate this ecological reality into our social practice by defending an absolute right to rest. We consciously reduce the pressure to perform and produce; instead, we embrace periods of intentional stillness.

In conventional settings, resting is often viewed as a brief pause between tasks. However, when we observe a field lying fallow, we understand that the soil is engaged in deep and vital work, slowly replenishing its nutrients for future seasons. We apply this principle directly to our community by defending the right to sit quietly together without the need to produce a tangible outcome. By accepting the limits of our own influence, we maintain an environment where learning is sustained by mutual care. In this way, the garden organically functions as a space of salutogenic design (Antonovsky, 1987; Peters & D'Penna, 2020). However, we intentionally avoid framing this rest as a clinical tool for mental recovery merely to prepare us for more work. Instead, this stillness serves as the fundamental birthplace of political and ecological imagination. In a world where mainstream narratives often suggest that everything is inevitably violent or already lost (Krenak, 2019), taking the time to rest and imagine together becomes a necessary act for building emotional resilience and a common home.

4. Discussion: The invisible harvest and horizontal knowledge

When we evaluate the outcomes of our time in the dirt, we look beyond the physical plants we manage to grow. In any natural ecosystem, the most vital processes often occur beneath the surface, where

roots and organic matter quietly build the long-term fertility of the soil. We observe a similar dynamic within our learning community, a phenomenon we describe as the invisible harvest. Frequently, our actual crops do not survive due to degraded soil, a plant being in the wrong place, or our own lack of practical experience. However, we notice that these literal losses still provide profound nourishment for our group. The true yield of our shared practice is not measured in baskets of produce. Instead, it is found in the moments of quiet connection, the patience cultivated during a difficult season, and the trust established among our diverse group of volunteers. As we slow down to the rhythm of the earth, we experience a renewed sense of ecological literacy (Orr, 1992). We begin to understand our environmental responsibility not as an abstract theory, but as an embodied reality, recognizing the deep interconnectedness of all life through the lens of interbeing (Thich Nhat Hanh, 2013). This perspective aligns with the work of Arturo Escobar and colleagues (2024), who emphasize that recognizing the deep relational webs of our world is essential for nurturing new ways of living together. We observe how the repetitive act of tending to the earth gently tends to the social fabric of our group. Even when the physical garden remains messy and the visible yield might seem small, this unseen harvest leaves our community more resilient and deeply rooted in the physical reality of Madeira. The island experiences a constant flow of temporary arrivals. Within the structural framework of the university, exchange students often interact with the broader geography of the island primarily through observation. They might treat the surrounding physical landscape as a beautiful but distant background for their academic studies. Our small garden occupies a distinct space where these different realities intersect. It serves as a tangible bridge connecting the transient energy of the campus directly to the soil of the local neighborhood. Tending to the dirt creates an opportunity for a transition from transient to inhabitant (Orr, 1992). When international volunteers gather to move dirt alongside lifelong neighbors, their connection to the island changes. Like a transplanted cutting that slowly extends fresh roots to sense the local soil chemistry, these temporary residents develop a tactile attachment to the place. This observation resonates with what Tim Ingold (2011) notes about inhabiting a world, where true understanding grows from continuous and direct participation in an environment rather than passive viewing.

We learn to see our shared space as a living piece nestled right between the mountains, the forest, and the sea. This growing awareness of the wider ecosystem extends beyond the boundaries of the property when we leave to walk together on group hikes. Moving through the landscape as a collective (Bertolotti et al., 2024; Gros, 2014) helps everyone comprehend how our local soil connects to the larger environmental rhythms of Madeira. As our community weaves international exchange students with local volunteers, our small garden becomes a site for cosmopolitan localism (Kossoff, 2019; Manzini, 2015). People from vastly different academic backgrounds and geographic origins bring their unique perspectives to the same physical space. When these diverse worldviews meet, we often encounter generative friction (Svare et al., 2023). Rather than viewing these moments of disconnect as failures, we approach them through the physical metaphor of a compost pile. In the same way we gather dead leaves and broken branches to slowly decay, we allow our misunderstandings and failed assumptions to break down into something useful. We watch how rigid theoretical frameworks soften when exposed to the daily messiness of the garden, a quiet process of epistemic composting that transforms friction into shared understanding. By letting our expectations decompose together, we engage in our own practice of regenerative participation. It is a tactile process of navigating uncertainty through shared action, where we learn to adapt and grow alongside the garden. We observe how our collective reflections slowly grow in the rich soil of our shared mistakes. This grounded approach functions as a form of transdisciplinary learning, which acts as a key leverage for sustainability transformations (Barth et al., 2023).

5. Conclusion: Soil porosity and the practice of gentleness

As we reflect on the broader educational value of our shared project, we consider how our localized space interacts with the larger institution. To understand this relationship, we observe the biological concept of soil porosity. Healthy soil requires open spaces to allow water and air to flow freely through the earth. We apply this ecological mirror to our relationship with the university. By maintaining a porous boundary, we invite ideas and volunteers to move organically between classrooms and our quiet garden. The university provides the structural support that allows this space for shared dialogue to exist. In return, our practice offers a grounded space for students to experience a different rhythm of learning (Orr, 1996), gently serving as a social infrastructure of care. We observe how careful and deliberate attention to local conditions can create more resilient systems and that a meaningful educational experience often emerges from small, quiet interactions. Like a patch of mycelium that connects specific elements of the forest floor, our community offers a subtle point of connection. When individuals spend time tending the dirt, they often carry that tactile perspective back into their own life. We realize that our goal is not to engineer a rigid solution for the deep systemic issues of society. Instead, we embrace a practice of gentleness, a deliberate choice to step

back, observe, and care for our immediate environment without demanding that it be perfectly fixed. By weaving two distinct modes of learning together, we learn how to live side by side as companions, experiencing together the natural cycles of growth and decay, and deeply feeling that we are an active part of nature. Through this shared presence in the dirt, we ensure that practical care and academic reflection continually nourish one another.

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DEVELOPING WORK-RELEVANT DIGITAL COMPETENCIES IN RURAL SECONDARY EDUCATION: INSIGHTS FROM HOMA BAY, KENYA

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Abstract

The growing demand for digitally competent employees in rural Kenya contrasts sharply with the limited technological resources and digital training capabilities in rural schools. While Kenya's Competency Based Curriculum (CBC) represents an important government initiative to integrate digital skills into education, its implementation faces significant challenges in rural areas where schools struggle with insufficient ICT infrastructure, limited teacher digital competencies, and minimal student access to technology. This mixed-methods study examines the critical gap between industry requirements and educational capacity in Homa Bay County, investigating how these limitations impact workforce readiness and local economic development. The study addresses four central research questions: (1) What is the gap between industry-required digital competencies and existing digital skills among teachers and students in rural schools? (2) How do current ICT competency levels compare against the DigComp framework? (3) What barriers and opportunities affect the development of work-relevant digital competencies? (4) What strategies could address these challenges? The research draws on data collected across three secondary schools and ten local industries. The methodology combined surveys of teachers' and students' digital competencies aligned with the DigComp framework, industry needs analyses, technical assessments of school ICT infrastructure, and an analysis of CBC implementation challenges. Results reveal significant misalignments between CBC objectives, current educational capacities, and industry needs, including how the digital competency gap affects both CBC implementation and workforce development in rural contexts. Accordingly, a digital teaching strategy was implemented combining solar-powered ICT infrastructure, low-energy digital devices, and a structured teacher development programme aligned with both DigComp and CBC requirements. The strategy emphasises practical applications through Learning and Work Tasks integrating real-world industry problems.

Keywords: *Digital competencies, work-based learning, rural education, teacher development, educational technology.*

1. Introduction

Digital competence is now a fundamental prerequisite for workforce participation across economic sectors worldwide. In Kenya, the government responded to this imperative through two interconnected policy reforms: introducing the Competency Based Curriculum (CBC) and in 2017, restructuring the education system from the 8-4-4 framework to a 2-6-3-3-3 model, explicitly mandating technology integration in learning at all levels (Ministry of Education Republic of Kenya, 2018; Kenya Institute of Curriculum Development, 2023).

Homa Bay County in western Kenya exemplifies this divergence. Its 2015 ICT Roadmap articulated a vision for digital transformation. Yet, by 2018, the County Integrated Development Plan documented a near-total absence of internet access in rural sub-counties, a county ICT department of only six staff members, and a mobile phone penetration of 85.6% alongside practically no fixed-line services (County Government of Homabay, 2018). Regional studies confirm that 44% of public primary schools in the county had no ICT-trained teacher (Kembo et al., 2019), with comparable deficits in secondary schools.

Conversely, the county's labour market is evolving. The growing services sector in banking and telecommunications is generating employer demand for digitally competent graduates, a demand that the current school system does not meet. This structural misalignment between educational output and labour market requirements has motivated the DEVISE4KE (Digital Education for Vocational and ICT Skills

Enhancement in Kenya) project which targets three rural mixed secondary VET schools in the county: Kiabuya, Miramba, and St. Joseph Olando.

2. Theoretical and conceptual framework

This study integrates three frameworks to guide teacher development and curriculum design. The DigComp 2.2 framework (Vuorikari et al., 2022) serves as the primary analytical lens, defining digital competence across five areas: Information and Data Literacy, Communication and Collaboration, Digital Content Creation, Safety, and Problem-Solving. It enables standardised, international measurement of competency gaps from Foundation to Specialised levels.

Pedagogically, two complementary models inform the design of teacher development and classroom practice. The SAMR model (Puentedura, 2024) categorises technology integration into four levels (Substitution, Augmentation, Modification, Redefinition). The TPACK framework (Mishra & Koehler, 2006) identifies the essential intersection of Technological, Pedagogical, and Content Knowledge for effective teaching.

Learning and Work Tasks (LWTs) operationalize these frameworks didactically in classroom practice. Rooted in the University of Bremen's Kompetenzwerkstatt approachLWTs place learners in authentic, problem-based scenarios drawn from real work or community contexts, structured across four phases: acceptance, planning, implementation, and conclusion. This approach is consistent with Kenya's CBC emphasis on practical, inquiry-based, and competence-oriented learning (Kenya Institute of Curriculum Development, 2023), and is particularly well-suited to the Homa Bay context because LWTs are designed to function with low-energy devices and offline content. This directly addresses the documented constraints.

3. Research design and methodology

This study employs a mixed-methods, design-based research (DBR) approach. DBR is appropriate where the aim is both to generate understanding of a problem in a specific context and to develop and refine an intervention in response to that problem (Anderson & Shattuck, 2012). Data were collected across two strands: a needs assessment strand and an implementation strand, the latter providing the evidence base for evaluating strategy design.

3.1. Needs assessment

Surveys were conducted over six months at the three previously-named secondary schools and ten local industries in Homa Bay County. 34 teacher across the three schools assessed self-reported digital competence across all five DigComp 2.2 dimensions using a four-point scale (1 = no knowledge; 4 = fully mastered). An additional module examined pedagogical dimensions against the DigCompEdu framework on teaching and learning, assessment, empowering learners, and facilitating learners' digital competence. A parallel student survey evaluated data on device access and competence levels.

Representatives from ten Homa Bay County companies in manufacturing, trade, banking, telecommunications, tourism, and agricultural services rated the importance of transversal skills and DigComp competence areas on a four-point scale (1 = not important; 4 = very important).

Technical infrastructure assessments were jointly conducted through on-site inspections at each school by Rongo University and the University of Bremen. Inspection protocols recorded structural conditions, electrical installations, sun exposure, and space for ICT room development. A photovoltaic feasibility analysis was subsequently conducted using NASA POWER Data Access Viewer and PV Watts data.

3.2. Scope and limitations

The industry sample (n = 10) and teacher sample sizes reflect the rural context and should be understood as locally contextualised qualitative-quantitative data rather than as statistically representative national samples. Findings are reported accordingly. The study design does not include a post-intervention competence measurement at the time of writing; learning outcome effects of the digital teaching strategy remain a subject for longitudinal follow-up research.

4. Findings

This study employs a mixed-methods, design-based research (DBR) approach. DBR is appropriate where the aim is both to generate understanding of a problem in a specific context and to develop and refine

an intervention in response to that problem (Anderson & Shattuck, 2012). Data were collected across two strands: a needs assessment strand and an implementation strand, the latter providing the evidence base for evaluating strategy design.

4.1. Research question 1: The industry–school digital competency gap

Industry survey results reveal a strong demand for digital skills, with 90% of respondents rating collaborative problem-solving as 'very important' and 80% prioritising continuous learning and safety. While industry also highly values information literacy (70%), a digital mindset (60%) and transversal skills such as adaptability and resilience, teacher surveys document critical deficiencies across all five DigComp areas, particularly in evaluating information credibility and managing digital identity. Digital content creation remains the most acute deficit, as the vast majority of teachers lack the confidence to perform category-specific tasks. Student results show an even deeper deficit due to a lack of device access and ICT-trained staff, a situation compounded by an attitudinal gap where employees perceive digital competencies as 'nice-to-have' rather than essential (Strategy Report Homa Bay, 2024).

4.2. Research question 2: DigiComp comparison

Mapping teacher self-assessment results against the DigComp proficiency scale (Foundation → Intermediate → Advanced → Specialised) reveals that across all five competence areas, the majority of teachers in the sample did not demonstrate proficiency beyond the Foundation level for most sub-competences, with partial exceptions in basic Information and Data Literacy. The DigComp teaching strategy for the project accordingly set Intermediate to Advanced (proficiency levels 3–4) as the target competence level for teachers before they proceed to develop student-facing content (Strategy Report Homa Bay, 2024). Table 1 summarises the documented gap across all three stakeholder groups:

Table 1. Competency Gap Summary by DigComp Area.

DigiComp Area	Industry (% very important)	Teachers (self-assessment)	Students (device access / competence)
Information & Data Literacy	70-80%	Moderate; fake-news evaluation and information organisation weak	No or minimal device access; low/no competence
Communication & Collaboration	60-80%	Basic email only; majority uncertain beyond that	No or minimal device access; low/no competence
Digital Content Creation	50-70%	Majority not confident; few demonstrate competence	No or minimal device access; low/no competence
Safety	80%	Weak area across respondents	No or minimal device access; low/no competence
Problem-Solving	60-80%	Not confident beyond basic level	No or minimal device access; low/no competence

Source: Strategy Report Homa Bay (DEVISE4KE, 2024); industry and teacher survey data.

4.3. Research question 3: Barriers and opportunities

Rural digital transformation faces three primary structural barriers: the absence of grid electricity at school sites, a near-total lack of ICT-trained teachers, and a deficit of secure physical infrastructure for device storage. These primary constraints are exacerbated by secondary barriers such as unreliable rural mobile data, environmental risks like dust and humidity, and severe financial limitations regarding equipment maintenance. However, significant opportunities exist, as the region's average of 5.27 peak sun hours per day and unshaded corrugated iron roofs provide ideal conditions for photovoltaic energy generation (NASA POWER Data, cited in Strategy Report Homa Bay, 2024). Moreover, the high local mobile phone penetration rate of 85.6% (County Government of Homabay, 2018) demonstrates basic device familiarity, while the CBC policy framework together with industry demand creates necessary institutional and economic incentives for project success. The CBC policy framework and industry demand for digital skills create institutional and economic incentives aligned with the project's objectives.

5. Digital teaching strategy

The digital teaching strategy developed in response to these findings integrates three interdependent components: energy infrastructure, ICT equipment, and a phased teacher development programme culminating in the co-creation of Learning and Work Tasks.

5.1. Infrastructure rationale

The photovoltaic feasibility analysis established a daily energy demand of 15.4 kWh for a functional ICT classroom, including a 20% safety margin, leading to an average monthly consumption of

407 kWh. Among the three evaluated system options, the 6.7 kW system (839 kWh/month) was selected to maximise direct solar usage and minimise battery dependency. This is essential given the limited access to technicians in rural Homa Bay (Strategy Report Homa Bay, 2024). For student hardware, a tablet-with-keyboard configuration was chosen over laptops or Raspberry Pi setups due to its superior energy efficiency (20 W per device), offline capability, and local technical support. This hardware pairs with an offline-first laboratory design, using a local intranet server to provide educational resources without requiring active internet connectivity.

5.2. Teacher development pathway

Because teacher competence is the primary pedagogical bottleneck, the strategy prioritises teacher development as a prerequisite for student-facing digital education. The DigComp framework was chosen over the more advanced DigCompEdu, to transform teacher mindsets about technology before they are expected to produce content for their students' (Strategy Report Homa Bay, 2024, p. 26). This was a strategic decision for teacher digital competence to precede and underpin teacher digital pedagogy.

The teacher development pathway operates in four stages. In Stage 1, teachers individually upskill digitally through completing free online courses and self-assessment to achieve Intermediate to Advanced proficiency (levels 3–4) across all five DigComp areas. Stage 2 engages teachers with Learning and Work Tasks as both learners (experiencing the pedagogy as students) and designers (developing tasks for their own classrooms). Stage 3 involves masterclass workshops (LTTAs) focused on innovative, interactive lesson design. Stage 4 implements a train-the-trainer model to build institutional capacity across the broader school faculty.

5.3. Learning and work tasks and the task-manager

LWTs act as the pedagogical core of the student-facing strategy, developed by the teachers at each school and featuring locally-relevant tasks e.g. renewable energy installation and ICT entrepreneurship. Four LWTs were developed and require students to move through four structured phases (acceptance, planning, implementation, and conclusion) to build vocational competences and transversal skills (problem-solving, communication, initiative, adaptability).

LWTs were created and delivered using the Task Manager, a web-based authoring and learning environment developed by the University of Bremen. It was chosen for DEVISE4KE because of its low entry barrier, scalable task complexity, and a bandwidth-efficient design using links rather than uploads. The Task Manager is freely accessible and can be hosted on each school's own server (DEVISE4KE project documentation, 2024/2025).

The LWT on photovoltaic system installation (D3.2) exemplifies this integration: students use digital tools to simulate PV system performance and calculate energy generation, while simultaneously developing vocational competencies in system design, safety protocols, and maintenance — within a work-process-oriented task structure grounded in the real energy challenge facing their schools.

6. Discussion

The findings of this study contribute to the emerging body of research on digital education in resource-constrained rural contexts in sub-Saharan Africa in three substantive ways.

The tripartite gap between industry expectations, teacher competence, and student skills exceeds conventional supply-side accounts. A significant attitudinal dimension exists where employers view DigComp areas as essential while teachers and students perceive these as 'nice-to-have'. This indicates that effective strategy must address the perceived personal and professional relevance of digital. This challenge can be addressed through LWTs which grounded in authentic local contexts.

Secondly, the project's infrastructure design choices i.e., offline-first operation, solar energy autonomy, low-energy devices, offline-first content delivery, provides a transferable design logic for rural implementation. While most ICT-in-education interventions presuppose grid electricity and internet connectivity (Amutha, 2020; Das, 2019), the DEVISE4KE approach demonstrates that pedagogically functional, DigComp-aligned digital education is achievable within these constraints.

Thirdly, this strategy reflects a principled critique of top-down ICT rollouts by focusing on teacher development as a prerequisite, rather than a post-hoc consideration. Evidence on technology integration in education shows that teacher competence and confidence are stronger predictors of effective technology use than device availability (Mishra & Koehler, 2006; Punie & Redecker, 2017).

Outcomes from the DEVISE4KE teacher development programme show initial empirical support for this sequencing. Eighteen teachers (six per school) successfully completed the structured training pathway. They produced competence-based LWTs using the Task Manager platform. Notably, two sites had no ICT-trained teachers at the outset, suggesting the model works even under very constrained

conditions. Building on this, six of the teachers (two per school) are currently conducting student pilots using their self-developed LWTs (April–May 2026), with competence outcome evaluation at the time of writing.

Limitations of the current study warrant acknowledgement. The industry and teacher samples are locally contextualised and not statistically representative of Kenya as a whole. Additionally, while teacher development has yielded verifiable results, student competence data from ongoing pilots is not yet available, and the long-term sustainability of equipment and content maintenance remains untested.

7. Conclusion

The DEVISE4KE project addresses a severe multidimensional competence gap where industry demand for digital skills is high, but teachers face critical deficiencies and students lack device access. Structural barriers, including a lack of electricity and secure facilities, further constrain the implementation of Kenya's CBC reform.

The project's approach integrates solar-powered, offline-capable laboratories and a phased teacher development program grounded in DigComp 2.2. It treats teacher digital competence as a prerequisite for student education, by empowering 18 teachers to create and run competence-based LWTs based on authentic local vocational challenges and delivered through the Task Manager platform. Six teachers are now conducting a student pilot under evaluation (April–May 2026). Longitudinal research on student competence outcomes and the long-term sustainability of the model constitutes the next stage of the DEVISE4KE research programme.

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Note on sources: Data cited as 'Strategy Report Homa Bay (DEVISE4KE, 2024)' refers to the internal project deliverable compiled from primary data collected in the field. All other references are published external works. The DEVISE4KE project documentation (LWT concept, Task Manager description) refers to internal documents produced within the project.

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INTEGRATING LIVING LAB WEBINARS INTO UNIVERSITY TEACHING FOR DIGITAL AND SUSTAINABLE OPERATIONS

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Abstract

This communication presents an innovative teaching experience based on the design and implementation of a webinar (online seminar) linked to a Living Lab research project focused on the digitalisation of greenhouse agriculture. The activity was mainly addressed to university students at the University of Almería (Spain). The live (synchronous) version of the webinar was held with students enrolled in the course Quality and Environmental Management, and Business Administration. The objective was to bring into the classroom a real-life case illustrating the application of digital technologies in production contexts and operations management. The session was recorded for later use (asynchronous) in other degree programmes, thereby increasing its dissemination, reaching around 120 views. The webinar was developed within the framework of the CODECS project (Horizon Europe) and provided an applied demonstration of how data interoperability, monitoring systems and decision-support tools contribute to improving operational efficiency and environmental sustainability in complex production systems. Through interaction with researchers, technicians and Living Lab professionals, students engaged with real operational challenges in intensive greenhouse agriculture and collaborative innovation processes. Unlike conventional webinars, the activity was fully embedded in the curriculum and combined real data, stakeholder interaction and structured academic reflection within an ongoing research project. The experience was designed to strengthen applied learning by connecting previously delivered theoretical content with a practical case of digital transformation. The Living Lab approach was introduced as an innovation and learning environment under real conditions, where technologies are tested and improved in collaboration with multiple stakeholders, including farmers, technicians, researchers and students, emphasising co-creation and real-world problem solving as core pedagogical elements. Specifically, the activity sought to complement traditional lecture-based teaching through applied research-based learning, enabling students to observe the practical relevance of concepts addressed in class. It aimed to facilitate students‘ understanding of the role of Operations Management in resource-intensive environments, emphasising efficiency, productivity and sustainability as key managerial competences. Furthermore, it introduced digitalisation and data interoperability as essential elements for the integrated management of operations, quality and environmental performance, reinforcing a systemic and information-based approach to decision-making. From an academic perspective, the webinar format encouraged active learning, critical thinking and analytical skills through direct contact with professionals and real data, fostering student engagement and development of transversal competencies. The data were collected through a structured Google Forms questionnaire completed by 119 participants and analysed using descriptive statistics, including Likert-scale items and basic comparisons between groups (live vs. recorded), complemented with questions related to the recorded session. The results revealed increased motivation and a better understanding of digital transformation and sustainability, supported by consistently high mean scores across all evaluated dimensions. The study analyses the potential of ‘Living Lab’ experiences delivered via webinars as innovative, transferable and replicable teaching strategies in higher education.

Keywords: *Learning, sustainability, digitalisation, agriculture, interoperability.*

1. Introduction

The teaching experience described here is based on two major, interrelated factors: firstly, the development of the European CODECS project and its Agroecological Living Lab in Almería; and secondly, the content and skills previously covered in Quality and Environmental Management and

Business Administration modules, taught as part of the bachelor's degree in Labour Relations and Human Resources.

Firstly, CODECS (Maximising the CO-benefits of Agricultural Digitalisation through Conducive Digital Ecosystems) (CODECs Project, 2022) is a European research and innovation project funded by the Horizon Europe programme, running for four years (2022–2026). Its aim is to analyse and maximise the environmental, economic and social benefits of agricultural digitalisation, addressing both opportunities and barriers associated with the adoption of digital technologies. The project combines knowledge generation, demonstration and transfer, assessing the impact of efficiency, resource use, and sustainability in agricultural systems.

The literature on e-learning and online learning indicates that well-designed synchronous formats can be effective tools for supporting applied learning in higher education (Fernández-Cerero & Montenegro-Rueda, 2024; Meng et al., 2023). This perspective is complemented by Living Labs and digital ecosystems frameworks, which emphasise the integration of digitalisation into real-world contexts to improve sustainability, operational efficiency and value creation in line with their role as spaces for experimentation and co-creation with multiple stakeholders (Herth et al., 2025; Morales et al., 2024).

One of the central elements of the project is the development of a network of Living Labs across European agricultural contexts. Our Living Lab, focused on data interoperability in greenhouse horticulture, is located in a 1,900 m² experimental greenhouse at the IFAPA experimental station near the University of Almería, equipped with technologies that reproduce real commercial production conditions. It integrates climate control, irrigation and fertigation systems, energy monitoring, soil and climate sensors, renewable energy production and resource reuse.

The integration of these systems enables addressing a key challenge in agricultural digitalisation: the integration of data from multiple devices to support operational decision-making, (Timpanaro et al., 2024).

Secondly, the teaching experience is based on the content previously covered in the modules. In the Quality and Environmental Management, students had worked on quality management, ISO standards, total quality management models, environmental management, system integration, and quality and environmental auditing. This provides a theoretical basis for analysing how digitalisation and data interoperability support continuous improvement, operational efficiency and environmental performance, in higher education contexts (Van Wart et al., 2025).

In the Business Administration module, students had examined the organisation as a system, functional areas, Operations Management, planning and control, business strategy, innovation, social responsibility and sustainability.

The integration of the webinar into the curriculum allowed students to connect theoretical concepts from Quality and Environmental Management and Business Administration with a real-world case of digital transformation in greenhouse agriculture. This alignment between course content and the Living Lab experience supports applied learning and reinforces key Operations Management concepts, including efficiency, process control and sustainability.

2. Objectives

The overall aim of this paper is to present and analyse an example of teaching innovation based on the integration of a webinar (online seminar) linked to a Living Lab into university teaching of subjects related to operations management in various fields. The initiative has been designed to reinforce students' applied learning, linking the theoretical content previously taught in the classroom with a real-world case study of operations management, digitalisation and sustainability within a complex production environment such as intensive greenhouse agriculture.

The Living Lab approach is based on its role as an environment for innovation and learning under real-world conditions, widely used in higher education institutions to integrate sustainability, experiential learning and co-creation processes with external stakeholders, thereby fostering the connection between teaching, research and knowledge transfer. (Herth et al., 2025; Morales et al., 2024).

Specifically, the experience pursues the following teaching and training objectives:

- To complement traditional theoretical teaching through an activity based on an applied research project, enabling students to observe the practical utility of the concepts covered in class, in line with the principles of active and experiential learning, through engagement with real-world contexts (Rakha, 2025; Van Wart et al., 2025).
- To facilitate an understanding of the role of Operations Management in resource-intensive production environments, focusing on efficiency, productivity and sustainability, identified as key competencies in the contemporary training and management of such production systems (Van Wart et al., 2025).

- Bring the concept of the Living Lab into the classroom, demonstrating that it is a space for innovation under real-world conditions, where technology is tested and improved in collaboration with its users: farmers, technicians, researchers, students and businesses, highlighting its potential as a learning and co-creation environment with educational and social impact (Herth et al., 2025; Morales et al., 2024).
- Introduce digitalisation and data interoperability as key elements for the integrated management of operations, quality and the environment, reinforcing a systemic view of production processes and information-based decision-making (Herth et al., 2025).
- Foster active learning, critical thinking and analytical skills among students through direct contact with professionals, researchers and technicians in the sector, encouraging student engagement and the development of cross-disciplinary skills (Rakha, 2025; Sahito et al., 2025).
- Assess the potential of webinar and the Living Lab approach as innovative transferable and replicable teaching tools in Operations Management and Technology.

3. Methods

The methodology employed is based on the design, organisation and delivery of an online webinar, integrated as a complementary activity within the aforementioned modules. The webinar is conceived as a teaching tool that combines learning based on real-life cases, exposure to European research projects, and the involvement of professionals and technical experts from the sector.

This approach is consistent with recent studies highlighting the effectiveness of e-learning when pedagogical and technological aspects are properly integrated, and when active and contextualised student participation is encouraged (Fernández-Cerero & Montenegro-Rueda, 2024; Meng et al., 2023).

In an initial phase, the technological platform for the online session was selected and tested. Preliminary trials with Collaborate Ultra revealed limitations in image and audio quality, leading to improvements in audiovisual materials and the adoption of Zoom Pro, with fully revised session settings and recording system.

Care was also taken with the visual and communicative aspects of the activity, creating an initial PowerPoint presentation with a dynamic and attractive design, incorporating videos at the end and themed background images. The course's Virtual Classroom was used as a dissemination and access tool, hosting the information poster, the link to the session, a project questionnaire on Google Forms, an assessment activity designed specifically for this event, and a satisfaction survey.

The webinar took the form of a synchronous online session, open primarily to university students, though also to researchers, technicians and professionals interested in agricultural digitalisation. The methodological structure of the webinar was organised into several clearly distinct phases.

The live session was attended by students from the courses Quality and Environmental Management and Business Administration. In addition, the questionnaire responses included students from different degree programmes, with a predominance of agricultural-related studies (44.5%), followed by Quality and Environmental Management (21%), Economics and Business (13.4%) and Agri-food Business Management (11.8%). This diversity of academic backgrounds reinforces the applicability and the transferability of the experience across different educational contexts.

In the first phase, an introduction to the European CODECS project was given, explaining its context, objectives, duration, type of action and methodological approach. The role of digitalisation as a tool for improving the efficiency, sustainability and resilience of production systems was highlighted, linking these aspects to the theoretical content previously covered in class.

In a second phase, the concept of the Living Lab was presented as a space for innovation under real-world conditions, explaining the reasons for its location, the characteristics of the Almeria agricultural model, and the specific challenges associated with the intensive use of resources such as water and energy.

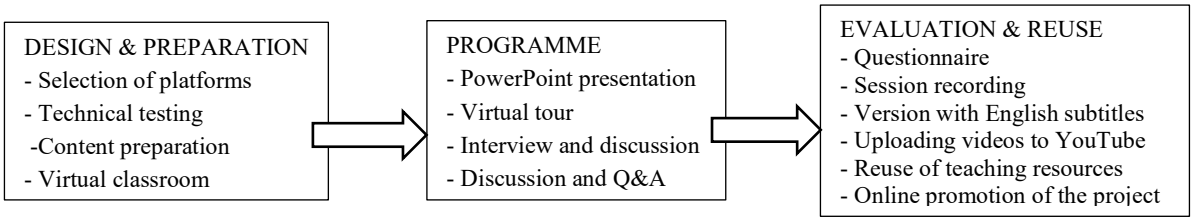
This was followed by a virtual tour of the Living Lab's experimental greenhouse, which used on-site videos to demonstrate, in an educational manner, the various digital technologies integrated into the farm. This allowed the students to visualise in a practical way the application of the concepts of Operations Management, process management and continuous improvement. Subsequently, an interview-debate was held with an expert in digitalisation and sustainable horticulture, moderated by the project's technical staff, encouraging interaction and critical analysis of the content presented.

Finally, time was set aside for questions and discussion, as well as for completing the project evaluation questionnaire and the webinar satisfaction form.

The session was recorded, and this video was subsequently uploaded to a YouTube channel, allowing it to be reused later as a teaching resource in other courses or subjects. In addition, another version with English subtitles was produced, suitable for publication on the European project's website.

For the use of the video in a recorded format for teaching purposes, an activity has been created featuring open-ended questions on the content to assess learning outcomes, in addition to using the Google satisfaction form.

Figure 1. Stages of the webinar methodology.



Source: by the authors

4. Results and discussion

From a teaching and learning perspective, the webinar enabled students to observe how theoretical concepts are applied in a real production environment. The session covered key aspects such as climate control, efficient water management, renewable energy production, CO_2 recovery, monitoring of agronomic and energy variables, and the interoperability of data generated by different systems.

The online format, combined with the virtual visit and the participation of external professionals, enriched the learning experience and reinforced students' perception of the usefulness of the course content, while also enabling the recording and reuse of the session. This interaction facilitated a deeper understanding of the benefits, barriers, and challenges of digitalisation from a professional perspective, strengthening students' critical thinking.

The experience also introduced the Living Lab approach as an innovation and learning methodology, highlighting its potential as a complementary teaching tool to traditional instruction. Students were able to identify the importance of data interoperability, system integration, and information-based decision-making for operations, quality, and environmental management.

The recorded webinar, available as an online resource on platforms such as YouTube, facilitates its integration into different courses and learning contexts, while strengthening the connection and synergies between university, industry, and the productive sector, aligning with knowledge transfer and educational innovation objectives. Quantitative results support these findings.

Table 1. Main results of the analysis.

	WEBINAR SATISFACTION	DIGITISATION BENEFITS	LIVING LAB IN TRAINING	N
Live	**6**	6	5,88	34
Recorded	5,72	6,07	5,84	84
Graduate	**5,91**	**6,15**	5,93	90
Master	5,46	5,74	5,62	28
Agricultural degree	**5,85**	**6,19**	**5,98**	66
Non-agricultural degree	5,73	5,87	5,69	52
Reliability (α)	0,93	0,94	0,92	118

Source: by the authors

The analysis shows high internal consistency across all constructs (Cronbach's alpha > 0.90), confirming the reliability of the measurement instrument. Mean scores indicate a consistently positive evaluation of the webinar across satisfaction, digitalisation benefits, and Living Lab dimensions.

Differences between synchronous (live) and asynchronous (recorded) participation are minimal, suggesting that learning outcomes are not significantly affected by the delivery format. However, results vary according to student profile, with undergraduate and agriculture-related students reporting higher evaluations, highlighting the importance of contextual relevance and prior knowledge in shaping students' perceptions of experiential learning approaches.

An increase in student motivation and interest was observed, particularly due to the connection with a real European research project with clear practical applications. These findings are consistent with recent literature on e-learning in higher education, which highlights the value of reusable digital resources

in enhancing the reach and effectiveness of learning activities (Fernández-Cerero & Montenegro-Rueda, 2024).

5. Conclusions

The experience demonstrates the potential of a webinar based on a Living Lab approach as an innovative teaching tool in the fields of Operations Management, Quality Management, and Environmental Management. The integration of a European research project into university teaching promotes applied learning and strengthens the connection between theory and practice, enabling students to engage with real-world challenges related to operations and sustainability.

The findings confirm that this type of activity enhances student motivation, perceived usefulness of the content, and understanding of key concepts, particularly when learning is contextualised within real production environments. Quantitative results support these conclusions, showing high levels of satisfaction and consistent evaluations across different dimensions, regardless of the delivery format (live or recorded).

In addition, the experience highlights the value of reusable digital resources, as the availability of the webinar on YouTube extends its impact beyond the live session and facilitates its integration into different educational contexts. It also reinforces collaboration and knowledge transfer between academia, industry, and the productive sector.

Overall, the study confirms the relevance of incorporating knowledge transfer activities and European research projects into higher education, contributing to more contextualised, practice-oriented learning aligned with professional demands. It also supports existing evidence on the effectiveness of experiential learning and real-world project integration as mechanisms to strengthen the link between theory and practice (Herth et al., 2025; Morales et al., 2024; Salinas-Navarro et al., 2024).

Finally, although the results are positive, the experience is limited to a specific educational and disciplinary context. Future research could explore its applicability in other fields and analyse its long-term impact on student learning outcomes.

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Van Wart, M., McIntyre, M., Zhang, J., Medina, P., Ni, A., & Njualem, L. (2025). The perceived importance of active learning techniques in online STEM courses. *Computers and Education Open, 9*. https://doi.org/10.1016/j.caeo.2025.100309

RETHINKING ONLINE STEM "BEST PRACTICES": EVIDENCE FROM A HISPANIC-SERVING INSTITUTION

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Abstract

Despite rapid growth in online higher education, evidence-based guidance for online STEM instruction remains fragmented, especially in Hispanic-Serving Institutions (HSIs). This article synthesizes findings from a National Science Foundation-funded mixed-methods project at a public Hispanic Serving Institution in the U.S. Southwest. Guided by a theoretical lens that foregrounds social presence, cognitive presence, and student readiness, the evidence base combines a cleaned Spring 2023 student survey dataset (N = 1,256 overall), 58 usable faculty surveys, descriptive project analyses, 12 faculty interviews, 12 student focus groups, and the peer-reviewed articles that emerged from the grant. Because the published papers used different inclusion rules and theme-specific subsamples, analytic Ns vary across individual findings. Across sources, three conclusions were consistent. First, STEM students valued structured and content-linked practice more than generic interactivity. Second, disciplinary differences were large enough that one-size-fits-all guidance was unreliable. Third, equity-oriented design depended less on lowering expectations than on increasing transparency, instructional presence, and coherent practice opportunities. Students did not favour minimizing lecture altogether; rather, they preferred substantial weekly lecture time when content was clearly organized and segmented. They also rated instructor-designed rehearsal, such as study guides, practice quizzes, and automatically graded practice problems, more highly than optional or loosely connected engagement tasks. Online testing was viewed as less anxiety-producing than in-person testing, but its credibility still depended on alignment among question design, timing, rehearsal, and feedback. Online labs showed promise, especially in hybrid or carefully targeted formats, but remained more context-sensitive than lectures or rehearsal. The article concludes with implications for faculty development, course design, and future implementation research, with lessons relevant both within and beyond U.S. HSI settings.

Keywords: *Online education, STEM education, active learning, Hispanic-Serving Institutions, equity in higher education.*

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1. Introduction

Online education is now a mainstream part of higher education, yet much advice about digital course design still treats disciplines as interchangeable. That assumption is especially risky in science, technology, engineering, and mathematics (STEM), where conceptual density, rehearsal, testing, and laboratory work often operate differently than in many non-laboratory subjects. It is also risky in institutional contexts, such as the Hispanic Serving Institutions (HSIs) in the United States, where students are more likely to combine study with paid work, family responsibilities, commuting, or uneven access to quiet study space and technology. Although broad reviews often find that online and face-to-face teaching can produce comparable learning outcomes under appropriate conditions, discipline-specific guidance for online STEM education remains relatively limited (Bernard et al., 2004; Nguyen, 2015; Kefalis & Drigas, 2019).

Although HSI is a U.S. policy label, the broader issue examined here is internationally relevant: whether widely promoted online best practices travel well across institutional contexts, student populations, and disciplinary traditions. This article examines that question through evidence from the NSF-funded pilot project – Improving Online STEM Education for Undergraduate Students at HSIs – at California State University, San Bernardino (CSUSB), a public university in the U.S. Southwest. Rather than assuming that generic online practices automatically transfer into STEM, the project asked a more targeted question: which practices remain effective in online STEM courses, which require modification, and which depend strongly on local context?

2. Theoretical grounding

As outlined in the original project statement, the inquiry is guided by three interconnected constructs: social presence (e.g., Garrison, Anderson, & Archer, 2023; Kehrwald, 2008), cognitive presence (e.g., Eom, Wen, & Ashill, 2006), and student readiness (e.g., Sieber, 2025). Within this framework, social presence in STEM is not simply about interaction for its own sake, but about purposeful peer engagement that enables rehearsal, protocol practice, and collaborative problem-solving. Cognitive presence addresses whether online instruction sustains intellectual rigor and conveys disciplinary enthusiasm, particularly in explanation-intensive fields. Student readiness underscores that course quality is also contingent on learners' ability to manage pacing, structure, and self-regulation in online environments.

In an HSI context, this perspective draws attention to students who are often balancing employment, family responsibilities, commuting, and uneven access to technology. Taken together, these theoretical lenses allow the project to examine not only where dominant online "best practices" hold, but also where they fall short in online STEM contexts.

3. Method

This article is a synthesis paper rather than a new standalone empirical study. It draws on three linked source types produced under NSF Award No. 2225206: (1) the cleaned Spring 2023 CSUSB student and faculty survey datasets; (2) internal project analyses and year-two qualitative follow-up materials; and (3) the peer-reviewed articles generated from the grant. The project ran from October 2022 through September 2025.

The quantitative phase produced 1,256 cleaned student responses overall and 58 usable faculty responses. The most detailed cross-disciplinary analyses centred on four focal disciplines: computer science and engineering, information and decision sciences, mathematics, and psychology. An additional comparison set from geography and environmental studies was collected but was not central to the main disciplinary analyses. Because individual papers applied different inclusion criteria and item-level exclusions, analytic sample sizes vary across published outputs; for that reason, the results below report patterns that were consistent across the project rather than treating a single N as applicable to every analysis.

The qualitative phase extended the survey findings through 12 faculty interviews and 12 student focus groups across the four focal disciplines. Across the project, five themes structured the inquiry: lecture strategies, rehearsal strategies, testing practices, laboratory design, and inclusion/belonging. The present article synthesizes the grant record together with the peer-reviewed papers that emerged from the project, including publications on changing student perceptions over time, online computing labs, rehearsal and testing, virtual avoidance, and active learning in online STEM courses (Hou, Ghasemkhani, Aldirawi, McIntyre, & Van Wart, 2024a; Hou et al., 2024b; Liu, Zhang, McIntyre, Seferoğlu, & Van Wart, 2025; McIntyre, Cui, & Hou, 2025; Van Wart et al., 2025).

4. Major findings

Three cross-cutting patterns appeared repeatedly across themes. First, students valued structure and content-connected activity more than generic interactivity. Second, disciplinary variation was substantial enough to make universal prescriptions unreliable. Third, equity-oriented online design worked best when it increased clarity, pacing, and instructor presence rather than when it diluted academic expectations.

Lectures. The project did not support a simple microlecture rule. Students did not appear to want lecture minimized; rather, they favored substantial weekly lecture time when it was clearly organized, broken into manageable segments, and supported by good audio quality, instructor enthusiasm, and responsiveness. Embedded questions and polling were viewed more positively than breakout-room activities during lectures. In other words, students wanted explanation plus purposeful interaction, not interaction detached from disciplinary mastery.

Rehearsal and formative assessment. This was the most consistent finding across project outputs. Students repeatedly rated instructor-created study guides, practice quizzes, and automatically graded practice problems as among the most helpful supports for learning. Required, low-stakes rehearsal was perceived as more helpful than optional rehearsal, and project analyses consistently showed a notable gap between the perceived value of structured practice and the consistency with which courses actually provided it. The active-learning paper reinforced this pattern: most active learning supports were viewed positively, but the highest-ranked ones were instructor-designed and closely linked to assessment rather than generic participation tasks (Van Wart et al., 2025).

Testing. Students generally preferred online exams and reported less anxiety online than in face-to-face testing. At the same time, the project did not suggest that online testing problems had disappeared. Faculty were more skeptical than students about fairness, integrity, and the degree to which online exams reflected learning. The clearest lesson was that assessment quality depended less on surveillance alone than on alignment: realistic time limits, appropriate question design, structured preparation, and timely feedback. The rehearsal-and-testing study reached a similar conclusion, especially in relation to the value of structured preparation before exams (Liu, Zhang, McIntyre, Seferoğlu, & Van Wart, 2025).

Labs. Laboratory instruction showed the clearest boundary conditions. Students were open to online labs, but not without qualification. Online lab formats were most credible when they were used for clearly defined learning goals, supported by recorded demonstrations or tutorials, and backed by visible instructor or teaching assistant support. Hybrid models were often more convincing than fully online substitutes for activities that depended heavily on equipment, tacit demonstration, or rapid troubleshooting. The online computing lab study likewise concluded that post-pandemic online lab design had improved but still required better targeting and stronger support structures (Hou et al., 2024b).

Inclusion and belonging. Most students reported generally positive online classroom climates, and the overall picture was stronger than deficit-based assumptions might predict. Even so, the evidence was not uniformly positive. A substantial minority reported weaker belonging, and about one in ten students reported feeling minimized in online classes. The project's equity implication was therefore not to reduce rigor, but to reduce avoidable ambiguity. Clear expectations, accessible support, visible presence, and predictable opportunities for practice appeared more central to equitable online STEM learning than symbolic appeals to inclusion alone.

Taken together, the findings suggest that STEM students do not reject active learning in principle. They reject forms of activity that feel weakly connected to mastery. Across the project, the most valued supports were those that helped students understand what they needed to learn, practice it in a structured way, and prepare for formal assessment.

5. Discussion and implications

The project's main contribution is both conceptual and practical. Much conventional guidance on online teaching treats more interaction as inherently better and often assumes that shorter videos, more discussion, and more breakout-room time will reliably improve outcomes. The evidence synthesized here suggests a more conditional view. In online STEM settings, students wanted active learning, but they preferred forms of active learning that were explicitly connected to content mastery, rehearsal, and assessment.

This finding matters beyond the U.S. HSI context. The specific policy label HSI is U.S.-specific, but the underlying conditions are not. Many institutions around the world serve large numbers of commuter students, working students, first-generation university students, and students with uneven access to study space or technology. In such environments, instructional structure is not the opposite of equity. It is often one of the main ways equity is enacted in practice.

Several implications follow. First, faculty development for online STEM teaching should be discipline-sensitive rather than built around universal slogans. Second, course design should not assume that the best solution is always to reduce lecture time aggressively; a better goal is to provide substantial explanation in a form that is well segmented, navigable, and responsive to student questions. Third, low-stakes, instructor-designed rehearsal should be treated as core course architecture rather than as optional enrichment. Fourth, online labs should be approached as a design challenge, not a binary question of whether they are possible. Some learning outcomes are well served by hybrid models, whereas others can be achieved online only when goals, materials, and support structures are carefully aligned. Finally, institutions seeking more equitable online STEM environments should prioritize transparency, pacing, presence, and coherent practice opportunities.

A further implication concerns evidence use itself. The project suggests that broad online best practices should not simply be imported from non-STEM contexts without testing whether they fit the cognitive and practical demands of STEM subjects. Context-sensitive adaptation is not a retreat from evidence-based teaching; it is a condition of applying evidence well.

6. Limitations and future research

Several limitations should temper interpretation. This article synthesizes results from one institution, even though that institution is large and demographically diverse. The published papers also draw on overlapping but not identical subsamples, meaning that theme-specific Ns vary. In addition, much

of the evidence concerns perceptions of helpfulness, fairness, belonging, or preparedness rather than direct measures of achievement or longer-term progression. These are important outcomes in their own right, but they do not answer every question about performance.

Future research should therefore move in three directions. First, the design principles identified here should be tested through implementation studies of model courses across different institution types, including HSIs, community colleges, and research-intensive universities. Second, future work should connect perception data more directly to achievement, retention, and progression in gateway STEM courses. Third, additional research is needed on discipline-specific lab design, belonging among first-generation and historically underrepresented students, and the opportunities and risks created by AI-enabled feedback tools in practice-heavy courses.

7. Conclusion

This project shows that online STEM instruction can be rigorous, inclusive, and effective when course design matches disciplinary demands and student realities. The most defensible conclusion is not that online STEM has a single best model. Rather, the project points to a set of stronger design principles: substantial but well-organized explanation, meaningful structured practice, assessment aligned with preparation, and deliberate instructional presence. Those principles travel better than generic formulas, both within HSIs and in other institutions serving students whose success depends on clarity, flexibility, and coherent academic support.

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FROM FIELD TO FEED: A SOCIAL NETWORK ANALYSIS OF A PHYGITAL EXPERIENTIAL LEARNING CASE IN HIGHER EDUCATION

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Abstract

The digital transformation of higher education requires innovative pedagogical models that bridge the gap between physical experiences and digital reflection. This study explores the role of the Teaching Learning Centre (TLC) at the University of Palermo as a strategic driver for "*onlife*" didactics. Central to this approach is the evolution of the educational visit through an innovative framework of experiential pedagogy. By connecting physical territory with digital interaction spaces, the project creates a "phygital" learning environment where students move from the field to the social media feed. Utilizing Social Network Analysis (SNA) via NodeXL, we analysed the communication dynamics of a joint didactic visit involving the Universities of Palermo and Coimbra. Results demonstrate that while institutional nodes act as primary hubs (Star Topology), gaining high levels of visibility within the institutional community from Meta Analytics, the digital re-elaboration of the experience not significantly effected peers' relation, although promoting students perceived self-efficacy and professional identity.

Keywords: *Educational visit, experiential learning, phygital, onlife perspective, teaching learning centre.*

1. The *onlife* challenge in higher education

The contemporary educational landscape is characterized by what Luciano Floridi defines as the "onlife" experience - a condition where the distinction between online and offline is no longer functional. Nowadays, younger generations are thoroughly accustomed to integrating digital devices into their everyday practices. Studying, eating, travelling, socialising, and playing are activities that can scarcely be imagined without the use of smartphones, web applications, social networks, and other digital tools. These technologies are profoundly transforming human experience and radically reshaping the ways in which individuals perceive and interact with the environments in which they live (Floridi, 2015; Morgan, 2015). In Higher Education, this shift demands a transition from traditional transmissive models to "phygital" environments that integrate physical presence with digital continuity. Recent research identifies online social media as a facilitator of students' collaborative learning and social interaction, fostering a more creative, dynamic, and research-oriented approach to education, particularly in the aftermath of the COVID-19 pandemic (Ansari & Khan, 2020). Within this theoretical framework, the present study investigates whether the use of social media platforms constitutes an effective strategy for establishing a causal relationship between the utilisation of digital tools and academic outcomes, about learning enhancement and students' self-efficacy.

Synthesizing seminal Social Learning Theory (Bandura, 1977) with contemporary educational research (Mohanty et al, 2024), (Dragseth, 2020), there is a consistent consensus that active student engagement and cohesive intergroup relations are pivotal for cultivating empathy and enhancing the quality of educational environments, including student-teacher interactions. Furthermore, current evidence substantiates a constructive correlation between positive peer interactions in physical settings and their effective transposition to digital learning contexts.

Moreover, learning by doing is the pillar of this educational set, linking students 'improvement to experiential knowledge, taking inspiration from the significant Kolb's theory: encompassing concrete experience (CE), reflective observation (RO), abstract conceptualization (AC), and active experimentation (AE) in all one cycle, learning activity widely increase its potential (Villarroel Henríquez et al, 2025). Following this framework, the physical visit to the partner University of Coimbra stands for CE, sharing digital storytelling via Facebook and Instagram represents the RO, the online discussion of the experience within the digital community symbolizes the AC and, finally, the production of new cultural content (the *feed)* embodies the AE.

In this context, connecting physical territory with digital interaction spaces like social networks, the project creates a "phygital" learning environment where students are encouraged to move from the field of the concrete experience to the social media feed of the digital dimension, fostering their sense of self-efficacy and professional growth shaping their vision *in the making* of the experience. Recent literature presents a variety of findings concerning the feasibility and effectiveness of different tools applied within learning environments, indeed, social media platforms can directly shape participants' interactions, as demonstrated also in communication studies on digital behaviours and online ecosystem experiences (Demeke, 2024) (Capriotti, Carreton, & Zeler, 2024a). Institutional communication, however, still largely relies on formalised and standardised modes of information delivery, often failing to generate high levels of engagement, except in cases identified in the literature as examples of good practice (Galioto, Pedone, Vantarakis, La Marca, & Bianco, 2025).

An illustrative example is provided by the previously mentioned study concerning the educational visit to Coimbra, organised in 2024 by an Italian university department with the aim of fostering students' soft skills, innovating pedagogical outcomes, and strengthening the sense of community belonging through online environment. The initiative produced particularly relevant outcomes for the present field of investigation. Specifically, the educational experience abroad acted as a significant catalyst for attention within the digital community, substantially increasing followers' engagement on the departmental Instagram account, as evidenced by analytics derived from the associated Meta Platforms Business tools. The educational experience in Portugal was documented by students through a storytelling methodology. Divided into three groups for their final assignment, students produced short-form videos in the format of "Reels," specifically designed for social media dissemination and aligned with the pedagogical objectives established for the evaluation process (Galioto, Pedone, Vantarakis, Tavares, & Bianco, 2025). So, in this perspective, Facebook/Instagram (Meta suite) become the mediator tool for data collection from students and contributed to evaluate students 'levels of engagement during this experimental set for innovative learning approach. That is the reason because we are intentioned to uncover if this platform, in that specific purpose, resulted to be suitable for develop interactions among learners and appropriate to improve educational outcomes in higher education.

2. The Coimbra case study. Institutional communication and experimental pedagogy

Background. While institutional communication often remains tethered to formal and conventional structures that struggle to achieve high engagement, specific "good practices" offer a different path. A notable example is the 2024 educational visit to Coimbra organized by an Italian department from the University of Palermo. This initiative aimed to foster soft skills among students, innovate pedagogical approach, and strengthen the community sense of belonging. The educational visit acted as a powerful attention catalyst within the digital community. Data from the Meta Business Suite of the departmental institutional account revealed a "peak" in interaction levels, particularly on Instagram, since it resulted to be the favourite platform by its specific target-audience - people aged 18–25 years. During the pedagogical trial, students were divided into three groups to produce "Reels" for their final assignments, as it has selected by teachers a digital storytelling methodology for self-reporting. This format served both as a pedagogical tool for assessment and as a medium for social sharing, with the aim of fostering interaction and engagement among young students. It follows that this "phygital" ecosystem model was built on three pillars: knowledge sharing, interactivity and engagement. In the aftermath of the pandemic, both educators and students recognised the potential of digital tools to overcome physical boundaries, enabling continuous collaboration regardless of geographical distance without diminishing the core significance of communication.

Furthermore, by transforming students from passive recipients into active producers of culture, these practices encourage the critical reinterpretation and re-elaboration of content. Finally, and perhaps most importantly, student engagement emerges as the primary driver of success: when students are acknowledged as active individuals within these networks, their perceived self-efficacy and sense of institutional belonging increase significantly (Galioto, Pedone, Vantarakis, Tavares, & Bianco, 2025).

Evidence. As revealed by the Meta statistics dashboard, in the period during which the departmental delegation organised and promoted the educational visits abroad September 2024, the institutional account produced a markedly positive impact on overall account performance, recording an increase of 326.9% compared with the previous month of August (Galioto, Pedone, Vantarakis, Tavares, & Bianco, 2025). The initiative generated substantial online engagement and stimulated widespread digital interaction among users, invited to using specific hashtags while tagging the institutional account. Moreover, audience engagement on Instagram and Facebook was particularly concentrated during the days in which the educational visit took place, as evidenced by the interaction trends presented in graphical visualization available from Meta. Particularly noteworthy was the observation that reinforcing

interpersonal relationships through in-person initiatives while simultaneously narrating these experiences on social networks — by emphasising memorable moments, tagging locations, mentioning participants, and encouraging collaborative posting — not only increased familiarity with departmental activities among the wider audience, but also provided the institutional management with valuable insights for designing future initiatives capable of engaging a broader public (Bader & Condrache, 2025).

Critical reflections. Mobile devices and social media offer unprecedented opportunities for academic collaboration and access to content. However, while these tools are often perceived by students as cost-effective and convenient, their efficacy in fostering deep peer-to-peer relations remains a subject of debate (Capriotti, Carretón-Ballester, & Losada-Díaz, 2024b). A critical question therefore emerges: are social networks genuinely effective in promoting collaborative learning, or do they primarily function as marketing tools for institutional communication? To address this issue in a more systematic and consequential manner, we conducted a social network analysis (SNA) of the educational visit experience to examine whether the observed network structure aligns with researchers' expectations.

The model aims to enhance students' academic performance by positioning digital cooperation not only as a communication tool but also as a knowledge domain that fosters creativity, research-oriented attitudes, and peer interaction (Galindo-Domínguez et al., 2024). The widespread diffusion of social media and internet-based communication technologies is reshaping young people's behavioural patterns, requiring higher education institutions to effectively integrate digital tools into learning environments. Nevertheless, further research is needed to assess whether social networks effectively support peer relationships and collaborative learning, or whether their primary value lies in institutional communication and marketing rather than in promoting student learning outcomes.

3. The social network analysis with NodeXL for the educational visit investigation

Methodology. SNA allows us to visualize the structure of communication and identify the roles of different actors, mapping the relational dynamics while measuring the Instagram's metrics of interactions (likes, mentions, and tags) (Milia & Trobia, 2011) . Data was extracted using NodeXL (Smith, 2013) from Instagram departmental account (*department sppeff*) searching for the specific hashtag "*#educationalvisitcoimbra*" to evaluating the number of connections per node (Degree), the extent to which a node acts as a bridge between other nodes (Betweenness centrality), how "close" a node is to all other nodes in the network (Closeness centrality) and the ratio of actual connections to potential connections (Graph density). Following a structural view, "vertices" are the fundamental discrete units or points of the graph, representing the entities within a system that are connected to one another. Using the term of "node" in SNA it is represented or an individual actor, an account (e.g., an Instagram profile) within the social ecosystem. Since "node" typically implies a functional role within a dynamic system, emphasizing the entity's capacity to process, store, or transmit information in the topology visualization of the communication network. Edges symbolize the digital interactions - specifically mentions and tags - that occurred during the educational visit. While the vertices represent the participants and institutional account, the edges map the relational fabric of the 'phygital' experience.

Results and analysis. The data extraction process produced a network composed of 20 vertices and 24 edges. The density of the connections reflects the degree of cohesion within the student group, while the concentration of edges around the institutional account node (*department sppeff*) identifies it as the principal relational hub of the network. Social Network Analysis (SNA) revealed the prevalence of a dominant "Star Topology" (Figure 1), highlighting a digital ecosystem in which the departmental account occupies a central communicative role. Within this configuration, the institutional profile functions as the primary hub, coordinating and directing most information flows among institutional accounts, teachers and students. From a quantitative perspective, the departmental account node exhibits a Betweenness Centrality of 165.5, the highest in the dataset (Table 1). In network science, this identifies the institutional profile as the critical "gatekeeper" or broker of information. It acts as a mandatory bridge between international partners (e.g., University of Coimbra) and the student body. More specifically, the *department sppeff* account emerged as the undisputed leader of the network, acting as the principal intermediary for nearly all interactions within the system. At the same time, the *Teacher 1* profile, in the role of contact person organizing the international experience, assumed the role of a bridging node. The visualisation of the network through the star topology model points to a highly centralised communication structure and supports a second relevant outcome of the SNA: namely, that the institutional communication strategy was effective in aggregating students around a shared narrative while simultaneously maintaining strong institutional leadership over the communication process. Although this represents a valuable outcome from the perspective of institutional marketing and advocacy, the "Hierarchical-Bottleneck" visualisation (Figure 2) also highlights the presence of potential communicative "constraints".

Figure 1. The "Star" Topology.

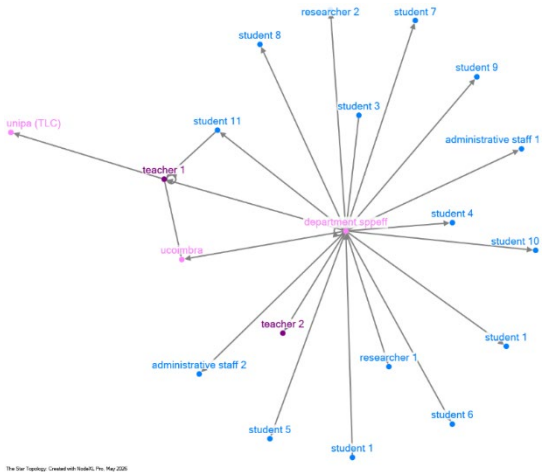
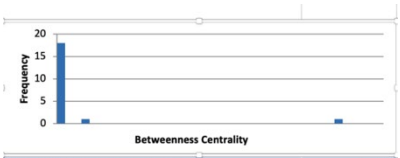
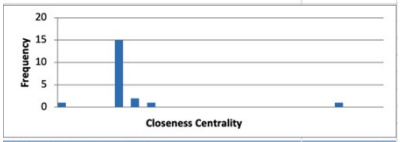


Table 1. Betweenness and Closeness Centrality metrics.

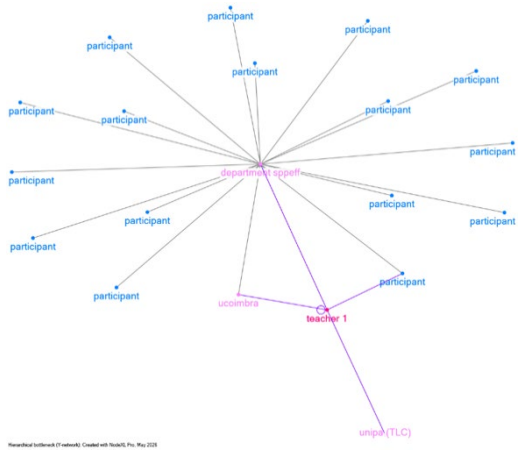


Minimum Betweenness Centrality	0,000
Maximum Betweenness Centrality	165,500
Average Betweenness Centrality	9,200
Median Betweenness Centrality	0,000



Minimum Closeness Centrality	0,365
Maximum Closeness Centrality	0,950
Average Closeness Centrality	0,521
Median Closeness Centrality	0,500

Figure 2. "Hierarchical-Bottleneck".



4. Conclusion and future implications

The results derived from this experiential learning approach indicate that the transition from the "field" to the "feed" encourages students to internalise and reinterpret their educational achievements. When students share reflections on the educational visit through social media and subsequently receive institutional validation - for instance through likes, reposts, or interactions from the departmental account - their perceived sense of self-efficacy appears to increase. The digital environment associated with institutional communication functions as a symbolic "screen" reflecting the construction of a professionalising identity. The findings suggest the emergence of a form of "bottom-up" validation process in which students move from the reality - the lived physical experience - to the digital dimension, understood as its narration and reinterpretation through social media practices (Mayer & Schwemmle, 2023). By tagging and interacting with the institutional hubs - university and departmental accounts -, students do not merely engage in social interaction; rather, they participate in a process of pedagogical re-elaboration through which personal achievements are aligned with the university's academic identity and values, although low engagement is visible among peers.

The structural network analysis conducted via SNA provides a robust empirical validation of the proposed conceptual framework, illustrating the tangible operationalization of pedagogical strategy into digital interaction. At the epicentre of this ecosystem lies the departmental account whose function as a strategic hub is unequivocally demonstrated by the data: the "*department sppeff*" node operates as the primary knowledge broker, serving as an essential bridge between the academic institution as the Unipa TLC and the student body. This centrality transcends mere communicative hierarchy, directly supporting the research hypothesis regarding interactivity with instructors and the institution and confirming that the departmental hub acts as the "gatekeeper" of information flow. The pivotal transition from the "field" (the physical experience) to the "feed" (the digital re-elaboration) is empirically reflected in the high density of

inward edges directed toward the central hub, validating the students' propensity for online knowledge sharing. In this context, the "star topology" identified by NodeXL is not merely a graphical model, but a representation of a symbolic validation process: by tagging the institutional hub, students seek a form of academic recognition that transforms individual storytelling into collective cultural assets. This process fuels the sense of institutional belonging and perceived self-efficacy that the theoretical model identifies as the primary drivers of student engagement (Allen et al, 2024). However, the significant dependency on the central node ("Hierarchical-bottleneck" structure) suggests a need to evolve toward more decentralized architectures. To fully maximize peer-to-peer interactivity, future pedagogical interventions must aim to transform this radial structure into a horizontal "mesh" community. In such a model, the student will become an autonomous, active node within a distributed "phygital" collaborative network. Future developments should focus on training students to transform into “nodes of influence” themselves, fostering horizontal collaborative learning that complements the current institutional leadership. To conclude, this study recognizes Teaching Learning Centres (TLCs) globally as feasible engine for implementing this innovative educational model, by leveraging educational visits as key venues for experimental transformation, what was once considered a mere supplemental field activity is reimagined as a complex learning ecosystem. In this framework, phygital experiences serve as representative markers of contemporary human advancement.

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INCLUSIVE EDUCATION AND NETWORK-BASED TRAINING: THE DEVELOPMENT OF A PEDAGOGICAL GUIDE WITHIN THE INTEGRAR PROJECT (UERJ)

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Abstract

The *Integrar Project – Training and Care as Tools for Inclusion and Social Transformation* is a university extension initiative developed by the State University of Rio de Janeiro (UERJ), in partnership with the Rio de Janeiro State Secretariat for Social Development and Human Rights. The project aims to promote social inclusion, psychosocial care, and continuing education for public-sector professionals, with a particular focus on families living in situations of social vulnerability and on children and adolescents with neurodivergent profiles. Grounded in an intersectoral, territorialized, and rights-based approach, the initiative articulates actions across the fields of education, health, and social assistance. From a pedagogical perspective, the project is structured around the inseparability of teaching, research, and extension, adopting action research as its central methodological framework. Between July and December 2025, the project implemented academic and educational activities—including seminars, training workshops, and case studies—aimed at the humanized qualification of public service professionals, particularly those working in education. These actions focused on strengthening qualified listening practices, supporting the ethical identification of situations involving violence, neglect, and psychological distress, and enhancing intersectoral referral and care networks. One of the project's main pedagogical outcomes was the development of the guide "Conhecer para Incluir", conceived as a practical educational tool to support professionals working in public service networks. Developed through an interdisciplinary and participatory process, the guide provides accessible guidance for inclusive pedagogical practices, the welcoming of neurodivergent children and adolescents, and the strengthening of intersectoral protection networks. The project's partial results indicate that Integrar is consolidating itself as a relevant extension experience, reaffirming the role of public universities in the production of socially grounded knowledge and in the strengthening of inclusive public policies.

Keywords: *Inclusive education, social protection networks, intersectorality, action research, university extension.*

1. Introduction

Over recent decades, socioeconomic transformations and urban inequalities have intensified situations of social vulnerability affecting Brazilian families, particularly in metropolitan territories marked by structural disparities. Understanding these dynamics requires recognizing territory not merely as a geographical delimitation but as a social and political category through which inequalities and differentiated access to rights are expressed. As Milton Santos (2005) argues, territory constitutes a socially produced space shaped by interactions among social actors, institutions, and economic structures.

In the state of Rio de Janeiro, these inequalities manifest through the combination of precarious labor conditions, unequal access to public services, and fragile articulation between social policies. Contemporary processes of labor flexibilization and economic instability have significantly affected the conditions of social reproduction among working-class families, expanding situations of vulnerability and insecurity (Antunes, 2018; Harvey, 2014).

These dynamics disproportionately affect women, who frequently assume central responsibility for caregiving activities within households. The intersection of gender inequality, labor precarization, and territorial disparities contributes to the persistence of structural inequalities and limits families' access to social protection mechanisms (Yazbek, 2016).

Within this context, the increasing visibility of children and adolescents with neurodivergent profiles or specific developmental needs highlights the limitations of fragmented institutional responses.

Although Brazilian legislation recognizes the rights of people with disabilities and guarantees inclusive education, the articulation between health, education, and social assistance services often remains insufficient.

Studies on public policy management emphasize that complex social problems require integrated institutional responses. Fragmented policy structures frequently lead to duplicated procedures, discontinuity of care, and limited effectiveness of public interventions (Bronzo, 2010; Cunill-Grau, 2014).

The Integrar Project – Training and Care as Tools for Inclusion and Social Transformation emerges within this context as an initiative aimed at strengthening social protection networks. Developed through cooperation between the State University of Rio de Janeiro (UERJ) and the State Secretariat for Social Development and Human Rights, the project seeks to promote professional training, psychosocial support, and knowledge production to support inclusive public policies.

This article analyzes the experience of the Integrar Project during 2025, discussing its contributions to the strengthening of social protection networks, the interprofessional training of public agents, and the development of pedagogical tools designed to support inclusive educational practices.

2. Territory and socio-spatial inequality

The analysis of social protection policies requires considering territory as a structuring dimension of inequality. Territory represents not only a physical space but also a field where economic relations, institutional arrangements, and access to public services are unevenly distributed (Santos, 2005).

Urban studies in Brazil highlight how socio-spatial segregation contributes to unequal access to services such as healthcare, education, and social protection. According to Villaça (2001) and Maricato (2015), Brazilian urbanization processes historically reinforced inequalities by concentrating infrastructure and economic opportunities in specific areas while relegating low-income populations to peripheral territories with limited access to public services.

Rolnik (2015) further demonstrates how processes of land commodification and housing financialization intensify spatial inequalities, reinforcing the exclusion of vulnerable populations from urban resources and services.

2.1. Labor precarization and social vulnerability

Transformations in global capitalism have intensified processes of labor flexibilization and precarization. According to Antunes (2018), the expansion of informal and unstable work arrangements has produced new forms of social insecurity, affecting families' ability to ensure stable living conditions.

In Brazil, unemployment and underemployment disproportionately affect young people and women. Data from the Brazilian Institute of Geography and Statistics (IBGE) indicate persistent gender inequalities in labor market participation and income levels.

The unequal distribution of unpaid care work further exacerbates these disparities, as women often combine precarious employment with domestic and caregiving responsibilities. These structural dynamics reinforce cycles of social vulnerability and highlight the importance of integrated social protection policies (Yazbek, 2016).

2.2. Intersectorality in public policies

Complex social challenges require coordinated responses across institutional sectors. The concept of intersectorality refers to strategies that promote collaboration between different policy areas in order to address multidimensional social problems (Bronzo, 2010).

Successful intersectoral initiatives typically involve shared institutional responsibilities, collaborative decision-making processes, and the creation of communication channels between public institutions. However, implementing such arrangements remains challenging due to administrative fragmentation and limited institutional capacity (Cunill-Grau, 2014).

2.3. Public universities and action research

Public universities play a strategic role in strengthening public policies through research, professional training, and knowledge dissemination. Action research provides a methodological framework that integrates knowledge production with social transformation by involving researchers and practitioners in collaborative problem-solving processes (Thiollent, 2011).

By fostering cooperation between universities and government institutions, action research contributes to the development of innovative methodologies, training programs, and educational tools designed to support public services and strengthen institutional capacities (Pires & Gomide, 2016).

3. Methodology

This study adopts a qualitative research design grounded in action research and institutional case study methodology. Action research was selected because it allows the simultaneous production of scientific knowledge and institutional transformation (Thiollent, 2011).

The empirical analysis focuses on the implementation of the Integrar Project during 2025. Data were collected through document analysis, participant observation during training seminars, and the systematization of discussions conducted in interdisciplinary workshops.

The training activities were structured around case-study exercises involving hypothetical situations of children experiencing social vulnerability. These exercises allowed professionals from different policy sectors—education, health, and social assistance—to collaboratively analyze possible institutional responses.

The analysis was guided by four central analytical categories: territory, social vulnerability, intersectorality, and professional training.

4. Results and discussion

The central empirical component of the Integrar Project consisted of interdisciplinary training seminars structured around case-study workshops. Participants collectively analyzed hypothetical situations involving children living in contexts of social vulnerability.

The discussions revealed a strong demand for multidisciplinary responses. Professionals emphasized the importance of coordinated actions between health services, educational institutions, and social assistance programs.

Participants also identified several institutional gaps, including insufficient professional training, limited availability of specialized services, and weak communication channels between public institutions. These findings reinforce the argument that institutional fragmentation remains one of the main barriers to effective social protection policies.

The pedagogical guide “Conhecer para Incluir”

One of the most significant outcomes of the project was the development of the pedagogical guide “Conhecer para Incluir”, designed as a practical educational resource for professionals working in public service networks.

The guide was developed through a participatory process that incorporated insights from training workshops, technical meetings, and the experiences of professionals working directly in vulnerable territories. It includes guidance for professionals in the social assistance network, particularly those working in CRAS, CREAS, and other institutions responsible for protecting children's rights. The guide provides recommendations on family reception, identification of rights violations, and intersectoral referrals to health and educational services. The material also includes operational tools such as checklists designed to support case monitoring and improve coordination between services.

Another version of the guide focuses on the educational environment, presenting pedagogical strategies to support teachers and school professionals working with neurodivergent children. The material highlights how relatively simple adjustments in classroom routines, communication methods, and sensory environments can significantly improve learning experiences and inclusion.

From an analytical perspective, the guide can be understood as a social technology derived from action research, since its development emerged directly from the interaction between academic research, professional practice, and territorial demands.

5. Conclusion

The Integrar Project demonstrates how cooperation between universities and public institutions can contribute to innovation in the field of social policies. By integrating research, professional training, and territorial intervention, the project strengthened intersectoral collaboration among health, education, and social assistance networks, creating spaces for dialogue and shared learning across different areas of the public sector.

The findings highlight that institutional fragmentation remains one of the main obstacles to the effectiveness of social protection policies, particularly in territories marked by persistent socioeconomic inequalities. Initiatives that promote continuing professional training, shared technical tools, and collaborative methodologies prove essential to strengthening coordination among public services and expanding the institutional capacity to respond to the complex demands affecting children, adolescents, and their families.

In this context, the development of the pedagogical guide **"Conhecer para Incluir"** represents one of the most significant outcomes of the project, translating academic knowledge and professional experience into practical guidance for everyday work within public service networks. By offering inclusive pedagogical strategies, guidance for welcoming families, and operational tools for intersectoral coordination, the guide contributes to improving the work of professionals operating directly in socially vulnerable territories.

The experience also highlights the potential of public universities to produce **social technologies** aimed at promoting rights and reducing inequalities. Unlike standardized and decontextualized solutions, the social technologies developed within the Integrar Project emerge from the interaction between scientific knowledge, professional practice, and territorial demands, which enhances their applicability and potential for replication in different institutional contexts.

Another important dimension of the project concerns its educational role, reaffirming the importance of the inseparability of teaching, research, and extension within public universities. By engaging students, researchers, and professionals from public service networks in collaborative learning processes, the Integrar Project contributes to the development of professionals who are more sensitive to social inequalities and better prepared to work in complex institutional contexts. In this sense, the experience analyzed demonstrates how university extension activities can constitute a privileged space for the production of knowledge directly connected to public policy challenges.

Furthermore, the project highlights the importance of inclusive education as a structuring axis of contemporary social protection policies. The school inclusion of neurodivergent children and adolescents requires not only pedagogical adaptations but also the construction of institutional networks capable of articulating schools, health services, and social assistance policies. Strengthening these networks is essential to ensure continuity of care and to expand opportunities for development and social participation for these children and their families.

Finally, the results suggest that initiatives based on cooperation between universities and public administration can represent relevant models of institutional innovation, particularly in contexts marked by territorial inequalities and limited coordination capacity within social policies. Expanding programs that integrate research, extension, and intersectoral training can significantly contribute to the consolidation of more coordinated, equitable, and territorially responsive social protection systems.

In this sense, the Integrar Project reinforces the strategic role of public universities in producing socially grounded knowledge and strengthening the institutional capacities of the State. By articulating professional training, applied research, and the development of pedagogical tools aimed at inclusive education, the initiative demonstrates how universities can act as active agents in the construction of more effective, democratic, and rights-oriented public policies.

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FOSTERING MENTAL CLARITY AND INTUITIVE THINKING IN THE DIGITAL AGE: RESULTS FROM AN INTERCULTURAL MENTAL TRAINING PROGRAM

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Abstract

In the era of the "attention economy," adults increasingly encounter cognitive overload, attentional fragmentation, and diminished capacity for sustained reflective thinking. While mindfulness practices are widely explored, the potential of structured philosophical thought-trainings combined with contemplative methods remains underrepresented in adult educational research. Phenomenological epistemological frameworks offer valuable resources for cognitive and emotional development, yet their abstract nature often limits accessibility.

This paper presents results from an annual, seven-month Intercultural Mental Schooling Path (IMSP). The program aims to cultivate critical thinking, inner freedom, emotional stability, and intuitive cognition through a structured engagement with the epistemology of freedom. The study investigates whether a meditative, socially embedded approach to philosophical texts contributes to mental clarity, internal coherence, and intercultural openness among adult learners in a global context. The IMSP follows a blended-learning design that integrates daily individual contemplative practice, digital learning tools, and peer-based social learning. Participants work with 627 curated "thought-cards" derived from *The Philosophy of Freedom* by Rudolf Steiner, which systematically guide reflection on autonomy in thinking and action.

Program effects were examined through retrospective surveys focusing on perceived cognitive, emotional, and spiritual development. Ongoing longitudinal analyses include standardized instruments measuring spiritual well-being (FACIT-Sp-12), openness to experience (IPIP-OtE), and internal coherence (ICS). Since 2020, 1,926 participants across eight languages have completed the program, forming a global learning community. This contribution presents data from Cohort 2023–2024 (n = 557, six languages). Post-intervention evaluations from this cohort (n = 142) indicate substantial self-reported improvements in broadened thinking (74%), gaining new insights (81%), increased mental clarity (67%), and enhanced concentration (51%). Qualitative data further suggest greater openness and reduced prejudice in social interactions.

The findings suggest that operationalizing abstract epistemological concepts into structured, contemplative daily practice may constitute an effective approach within adult education. IMSP illustrates how digital tools, blended-learning formats, and peer-supported reflection can renew phenomenological philosophical training in a secular educational context. The program provides a scalable framework for fostering cognitive autonomy, emotional stability, and intercultural competency, and contributes to the empirical exploration of philosophy-based mental training within lifelong learning and mental health research.

Keywords: *Philosophy of Freedom, metacognition, mental health, mental training, critical thinking.*

1. Introduction

In the ongoing effort to address complex global challenges and realize the United Nations Sustainable Development Goals (SDGs; United Nations, 2015), systems theorists point to a "divorce between inner and outer" approaches to sustainability (Wamsler & Bristow, 2022). While current strategies prioritize external technological solutions, there is an urgent need to link these actions with conscious internal development (Ives et al., 2023; Wamsler et al., 2021). To bridge this gap, frameworks

such as the Inner Development Goals (IDGs; Inner Development Goals, 2021) have emerged, emphasizing that society's collective capacity to resolve these "wicked problems" (Rittel & Webber, 1973) is fundamentally constrained by our internal cognitive state. This disconnect appears to be exacerbated by the realities of the contemporary "attention economy" (a concept coined by Simon, 1971). Recent analyses in cognitive science highlight the technopolitical economy of attention, exploring how digital platform architectures systematically capture and commodify human focus (González de la Torre et al., 2025). Within these digitally saturated environments, adult learners frequently engage in cognitive offloading (Gilbert et al., 2023). While this offers immediate functional efficiency, its unprecedented scale, exacerbated by the widespread integration of generative artificial intelligence, threatens to fundamentally alter our internal cognitive architecture. Habitual reliance on these systems to process information and generate thought risks cultivating "metacognitive laziness" (Fan et al., 2024) and bypassing the self-regulation required for independent thinking. Consequently, as digital platforms increasingly undermine cognitive autonomy (Susser et al., 2019), users face a gradual erosion of what Elgin (2013) defines as epistemic agency, the capacity to consciously monitor and direct one's own cognitive processes. This internal erosion is a real-world challenge that directly undermines the foundational goals of Awareness-Based Systems Change (Scharmer, 2018), an approach which posits that sustainable external transformation requires conscious internal development.

To address this need, we have developed an Intercultural Mental Schooling Path (IMSP) as a program for adult cognitive and philosophical development, utilizing a blended-learning design that integrates daily individual contemplative practice, digital learning tools, and peer-based social learning. The program's core curriculum is derived from Rudolf Steiner's *The Philosophy of Freedom* (Steiner, 1918/1964). Drawing on contemporary first-person research, this foundational text is utilized as a systematic framework for the introspective observation of thinking. Recent studies in phenomenological cognitive research suggest that such disciplined inquiries can be operationalized as methods for systematically investigating the inner dimensions of consciousness (Wagemann et al., 2018). This is further substantiated by methodological frameworks for "first-person experiments in thinking" and the investigation of pure conceptual processes (Ziegler & Weger, 2018). Within educational discourse, this framework is interpreted as a philosophical and pedagogical path of self-formation, providing a structured foundation for fostering mental autonomy and ethical individualism (Bach Junior et al., 2014). Over the course of seven months, participants systematically guide their reflection on autonomy in thinking and action, utilizing these phenomenological epistemological frameworks with the aim of rebuilding cognitive autonomy and the capacity for active perception.

While acknowledging the multidimensional depth of the original text, this study focuses on its potential measurable cognitive footprint. Because the program's curriculum inherently relies on everyday terminology rather than strictly operationalized cognitive constructs, this paper reports a purely exploratory pilot evaluation of the IMSP. By detailing participants' retrospective self-reported changes, we aim to systematically capture these subjective experiences, thereby offering initial hypotheses for future investigations and setting the stage to explore how these phenomenological shifts might conceptually align with established concepts in cognitive research.

2. Methods

Established under the name "The Annual Training Philosophy of Freedom," this program serves as the foundation for what we define within this research as an Intercultural Mental Schooling Path (IMSP). The intervention was designed as a path of spiritual and mental training, aiming to translate philosophical concepts into a tangible inner experience of thinking. The curriculum relies on 627 curated "thought-cards" derived from Rudolf Steiner's *The Philosophy of Freedom* (Steiner, 1918/1964), accessible either via a digital application or as a physical card set. Participants are asked to commit to a daily practice, dedicating 15 minutes to focused "meditative-thought work," a process of sustained concentration and cognitive rehearsal of specific philosophical propositions, over a seven-month period. This deliberate daily engagement aims to transform passive reading into an active, metacognitive phenomenological experience, described within the program's framework as cultivating a "life in thought." In this context, "life in thought" refers to the state where the act of thinking itself becomes a conscious and perceivable internal activity rather than a mere means for information processing.

The curriculum paces participants through 15 to 30 specific cards per week instead of reading the text sequentially for intellectual consumption. This slow, deliberate cognitive repetition is intended to engage the learners' willpower and foster a deep internal assimilation of the thought processes. To support this solitary meditative practice, the IMSP employs a comprehensive blended-learning social ecosystem. Participants receive weekly inspirational letters that provide thematic context and spiritual framing for the upcoming cards. Furthermore, the seven-month journey is anchored by nine global video conferences

featuring keynote presentations, shared mental-meditative exercises, and breakout rooms organized by languages, where participants engage in facilitated dialogue to deepen the philosophical content and share subjective experiences of their daily practice. To further sustain motivation and peer-supported reflection, learners are encouraged to form "buddy" (tandem) partnerships and regional practice groups. Together, these elements are intended to create a holistic educational framework that bridges intensive individual nonautomatic cognitive effort with a supportive global community.

To investigate these cognitive shifts, the Cohort 2023–2024 evaluation was structured as an exploratory-descriptive post-hoc pilot study. We designed a custom retrospective questionnaire informed by recurring anecdotal feedback from previous program cycles, where participants reported improvements in mental clarity, concentration, and willpower. Data collection occurred at the conclusion of the seven-month program using this newly developed instrument to further explore these recurring observations within a structured framework. For the participants, the final survey also served as an integral tool for pedagogical self-reflection and personal feedback at the end of their seven-month journey. The global Cohort 2023–2024 initially comprised 557 adult learners participating across six languages (English, German, Spanish, Russian, Chinese, and Czech). Participants self-enrolled via open digital recruitment channels and existing adult education networks. Demographic data were collected specifically from the subset of participants who opted to complete the retrospective evaluation (n = 142), with age being recorded in predefined seven-year brackets. The self-administered survey consisted of 74 quantitative items designed to measure perceived cognitive changes, emotional well-being, and spiritual experiences from the training. Quantitative items were assessed using 5-point Likert scales, ranging either from "not at all" to "very much" or "strongly disagree" to "strongly agree." Additionally, separate, optional open-ended questions allowed participants to provide free-text responses detailing their phenomenological experiences, what worked well, reasons for potential early termination, and desired support. Given the exploratory nature of this pilot study, data analysis was restricted to descriptive frequency distributions of these self-assessed changes, utilizing the open-ended responses strictly to provide qualitative context.

3. Results

Following the seven-month program, we recorded a final sample of 142 completed retrospective evaluations. Relative to the initial enrollment (N = 557), this represents a survey response rate of 25.5%. The sample (n = 142) consisted of 74.6% female and 21.8% male individuals, with 3.5% missing data. Regarding age distribution, the largest subgroups were participants over 70 years of age (28.2%), followed by those aged 63 to 69 years (23.9%) and 56 to 62 years (21.1%). Middle-aged respondents (42 to 55 years) accounted for 19.7% of the cohort, while younger individuals (up to 41 years) represented 6.3%. In the retrospective evaluation of the training’s impact, participants reported changes across several variables. Specifically, 74% of respondents noted a perceived broadening of thinking and 81% reported gaining new insights. Furthermore, participants reported perceived mental clarity (67%) and a capacity to concentrate (51%) following the seven-month practice. The evaluation also indicated shifts in additional domains of the participants' internal processes. Specifically, 59% of the cohort reported increased security in their thinking processes and 55% reported an improvement in overall mental health. Finally, 47% of the respondents noted a subjective strengthening in their willpower and 46% in their intuitive capacities.

The numerical data were supplemented by qualitative reflections provided by 79% of the respondents (n = 112). Participants described a perceived reduction of interpersonal boundaries, a sense of shared humanity across diverse cultural and national backgrounds, and an increased capacity to navigate difficult social interactions. Furthermore, participants noted that the shared engagement with the program's content functioned as a unifying element, with several responses highlighting the perceived resolution of previous misunderstandings or social discord. Regarding the structural elements of the training, qualitative feedback identified the curated "thought-cards" and the weekly introductory letters as supportive elements for engaging with the philosophical text. Participants also reported factors that hindered sustained engagement. Responses concerning desired support and early termination cited a lack of personal time due to professional and family obligations. Furthermore, participants requested more direct personal exchange, such as a peer "buddy" system, and noted technical or communicational hurdles during the onboarding phase.

4. Discussion

The pilot evaluation of the IMSP indicates that structured and contemplative engagement with philosophical texts, specifically the epistemology of freedom, is associated with high levels of perceived mental clarity (67%) and concentration (51%). By operationalizing Steiner’s concepts into an educational

context, the program can be conceptually explored as an "epistemic gymnasium." Within this framework, the curated "thought-cards" appear to serve as cognitive resistance training, requiring participants to transform passive reading into an active, self-directed observation of their own thinking processes. These findings align with literature suggesting that structured reflective and mindfulness-based interventions are positively associated with the cultivation of attention, cognitive flexibility, and emotional self-regulation (Mahalingam & Rabelo, 2019; Weare, 2019). This synergy potentially empowers IMSP learners to reclaim internal regulation, foster cognitive autonomy, and counter the passive cognitive offloading prevalent in digitally saturated environments. Furthermore, the observation that 81% of participants reported "new insights" provides preliminary support for the development of intuitive cognition. Through the empirical lens of naturalistic decision making, this can tentatively be viewed as rapid, experience-based pattern recognition (Kahneman & Klein, 2009; Woiceshyn, 2020). These findings offer initial hypotheses for future investigations into how the program's cultivated practice of "life in thought" might function as an epistemic technology for linking inner and outer development, a critical need highlighted in recent sustainability literature (Ives et al., 2023; Wamsler et al., 2021). Building on these preliminary hypotheses, future theoretical work must explore how the program's phenomenological state of "life in thought" conceptually aligns with established cognitive constructs, such as core executive functions (Diamond, 2013), cognitive flexibility (Dajani & Uddin, 2015), and epistemic agency (Elgin, 2013), to determine how these shifts can be most effectively classified and empirically measured.

The results of the quantitative analyses are further supported by qualitative feedback, which indicates that the developmental process may have supported a transition from reactive social patterns toward a more conscious and constructive social presence. Participants' reflections on resolving social friction and fostering a sense of shared humanity across diverse backgrounds suggest that the reported enhancements in social openness and the real-time observation of personal biases may represent a meaningful shift in the participants' interpersonal cognitive frameworks. Consequently, the IMSP's focus on the observation of thinking may translate into increased social agency, an enhanced capacity for active perception, and the ability to modulate interpersonal responses in complex cultural contexts. This dynamic reflects the core phenomenological principle upon which the program is built: that conscious inner activity must deliberately precede any effective outer action. Rather than merely adopting external behavioral guidelines, participants appear to be developing the underlying cognitive flexibility necessary to support Awareness-Based Systems Change.

While these results indicate potential for committed learners, the present outcomes represent descriptive phenomenological shifts rather than causal findings. Primary methodological limitations include the absence of objective digital activity tracking and a survey response rate of 25.5 percent. Low response rates are a common challenge in retrospective evaluations of uncompensated online programs. However, qualitative feedback also indicated that integrating the rigorous daily practice into professional and family life was a significant barrier for sustained engagement. This highlights a clear need for enhanced social scaffolding, which will inform future iterations through peer exchange mechanisms like the buddy system. Furthermore, the custom survey tool was exploratory and not psychometrically standardized. Consequently, the analysis remained descriptive, utilizing frequency distributions and anecdotal feedback to illustrate trends without inferential modeling. Finally, while self-reporting introduces potential recall and social desirability biases, the retrospective design may partially mitigate response-shift bias as participants evaluate growth through the cognitive framework acquired during training (Howard et al., 1979). To address these limitations, the active Cohort 2025–2026 utilizes a prospective longitudinal design. This ongoing phase integrates strict psychometric validation using established scales, including the FACIT-Sp-12 for existential well-being, the IPIP-OtE for openness to experience, and the Internal Coherence Scale (ICS). These quantitative metrics are complemented by qualitative methodologies, such as focus groups and interviews, to explore broader organizational impacts. For instance, initial data from a school faculty in Alicante suggest that the IMSP may enhance faculty cohesion and inspire educators to actively reshape their shared institutional spaces. By transitioning to this more comprehensive, mixed-methods framework, we aim to develop the IMSP into a scalable, empirical research model for future adult education.

5. Conclusion

The "divorce between inner and outer" approaches to global challenges highlights the need for profound educational interventions that directly address the fragmented reality of the attention economy. The descriptive data from our pilot cohort suggest that the IMSP may function not merely as a theoretical philosophy course, but as a potentially practical and scalable epistemic gymnasium. By empowering individuals to reclaim their epistemic agency and counter the passive over-reliance on digital cognitive offloading, such structured contemplative practice has the potential to foster the cognitive autonomy

required for true Awareness-Based Systems Change. Ultimately, practical countermeasures like the IMSP highlight a critical, often overlooked dimension of global problem-solving: sustainable external development must be anchored in sustainable human cognition. Equipping adult learners to navigate the digital age requires bridging this inner-outer disconnect from within. As learners engage in internal capacity building, the reported cognitive shifts appear to organically support the Inner Development Goals (IDGs), contributing to the broader foundation needed to address the SDGs.

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CHILDREN'S NARRATIVES OF BELONGING – A PARTICIPATORY ARTS-BASED STUDY IN DIVERSE SCHOOLS IN ENGLAND

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Abstract

The stories people tell about themselves and others, about who they are and where they belong, remain contentious and ongoing issues in education. Recent shifts towards child-centred pedagogies and inclusive practices highlight the importance of understanding how children themselves make sense of belonging. The value of listening to children's voices has been well established in the past decades. There also remains limited research into the experiences of children from migrant backgrounds in the UK, as most studies have focused on older children or those entering adulthood. Scholarship has centered on theoretical frameworks or school-focused strategies for 'achieving' a sense of belonging. The perspectives and experiences of migrant children remain underexamined. This presentation is based on a participatory, arts-based project exploring children's experiences of belonging and inclusion in school and their wider lives. The aim of the project was to investigate the interconnectivity in discourses on identity, otherness, belonging and inclusion – I am interested in how children experience, perceive, and contest these spaces. The project involved 27 children aged 10-11 in two diverse primary schools in England. A multi-methods approach was utilised, including focus groups, painting/drawing, storyboarding, co-analysis pinboards, and dance/drama performances. The findings indicated that children's narratives on belonging are expressed, defined, and contested in multiple ways, enmeshed in material and symbolic relationships with people, places, and objects. One key aspect I will discuss is how the personal and immediate objects in children's lives formed a part of their understandings of belonging, which raises questions about how children form attachments with classroom spaces. Furthermore, sites of 'differences' sometimes caused a sense of otherness but also formed opportunities for friendships and belonging to emerge. This presentation aims to contribute to the conversations around belonging in childhood, presenting a model of belonging that reflects the embodied, material, affective and political realities of belonging in children's school lives, and suggests implications for school practices.

Keywords: *Belonging, childhood, voice, migration.*

1. Introduction

Belonging is a multidimensional, dynamic process which can be understood through different theoretical lenses. For Antonsich (2010), "to belong means to find a place where an individual can feel 'at home'" (p. 646), which includes the domestic, material spaces associated with family, as well as the symbolic spaces of familiarity and safety. Thus, belonging is often associated with 'rootedness' and a sense of place, which is especially relevant to contexts of migration and the unfinished and multiple forms of children's belonging and self-identification (Ní Laoire, 2010; Moskal, 2015). Belonging is also entangled within political and historical discourses, related to processes of how social locations, identities, and emotional attachments are "assessed and valued by the self and others" (Yuval-Davis, 2011, p. 18). This has been called *the politics of belonging*. Central to my research is also the materiality of belonging and recognising the interactions of people, places and objects in relation to children's experiences (Ros i Solé et al., 2020; Youkhana, 2015). As Youkhana (2015) puts it, belonging is about the "complex relations that individuals have with other people, circulating objects, artefacts, and changing social, political and cultural landscapes, thus mirroring both the material conditions and the underlying power relations" (p. 10).

The stories people tell about themselves and others, about who they are and where they belong, remain contentious and ongoing issues in education. Research from different perspectives and ontologies has explored how young people navigate belonging and their identities in different contexts, for example, studies highlight young people's active engagement in processes of migration, friendships, and performing identities in relation to 'others' (Einarsdottir et al., 2022; Welply, 2022). However, there also remains limited research into the experiences of children from migrant backgrounds in the UK, as most studies have

focused on older children or those entering adulthood. As discussed above, scholarship also centres on conceptual frameworks for understanding belonging or school-focused strategies and measures for 'achieving' a sense of belonging (e.g., Goodenow, 1993). The perspectives and experiences of young migrant children and how they make sense of belonging in school and their wider lives remain underexamined.

2. Research approach

The aim of the project was to investigate the interconnectivity in discourses on children's identities and sense of belonging and inclusion in school and in their wider lives. The project worked with 27 children aged 10-11 in two culturally diverse schools in the North of England. Participants were invited to create artwork about a time they felt lonely, upset or happy at school, choosing from a range of creative methods on offer – painting, collage, drawing, narrative writing. Next, a storyboarding method was used and involved asking participants to 'tell a story of someone arriving at a new school'. These storyboards could have been based on their lived experiences, or imaginary stories, or a combination of both. During the workshops, participants were also invited to take part in focus groups where they shared their perspectives and experiences of belonging in school and beyond school. Then, participants were invited to interpret, clarify and discuss meanings and emerging themes using visual, interactive pinboards. Participants used coloured pens and post-it notes to add to/amend the data, and they selected some keywords and stories to explore further in the dance and drama workshops. Through these methods, views and experiences were brought to life in collaborative, exploratory, even fictional ways (Harvey, 2020). The data was transcribed and analysed using qualitative software, which was also applied to the visual data, and involved coding by visual content and triangulating with the meanings participants assigned to their artwork.

3. Findings and discussion

The findings indicated that children's narratives on belonging are expressed, defined, and contested in multiple ways, enmeshed in material and symbolic relationships with people, places, and objects. In particular, the ordinary and immediate objects in children's lives formed a part of their understandings of belonging ('my toys', 'my pocket money'), and possessions and objects as markers of belonging symbolised individuality – distinguishing between what is 'mine' and 'yours'. One participant, Fakhri, stated, "I belong to my football books". Asman also commented, "I belong to my paper and pencils", and Teresa responded, "true, 'cos you're an artist". These comments indicate social-material investments and highlight the potential agency of objects in the construction of identity.

The 'agentic capacities' (Martin, 2019) of seemingly ordinary classroom objects raise important questions about how children form attachments in classroom spaces. Juutinen et al. (2023) explored how very young children's belonging is constructed through material relations. Their work shows that objects, movement, touch, and play are key sites through which belonging is produced in early childhood settings. Like Martin (2019), my research found that ordinary classroom objects functioned in ways beyond their intended purpose, for example, to demonstrate status among peers (participants spoke about their pocket money) or playing with water bottles in the school toilets formed new friendships and social insiderness. Some participants spoke about how the objects and spaces in school remind them of home – for example, Imram reflected that the "high ceilings in school" remind him of his "house in Pakistan".

Children also shared experiences of struggling to belong at school, and this was often mediated through material and embodied spaces, for example, some storyboards depicted feeling overwhelmed at the size of the school as a newly arrived learner. Yeva, who had recently arrived in England from Iran, represented in her artwork the challenges she experienced during lunchtime:

> *Researcher: could you tell me about what you are drawing?*
> *Yeva: I feel sad because when I just came to this school, I think it was my first day, I lost my [lunch]band and I didn't know how to say. ...the dinner lady said you have to have a band to get lunch so I went outside.*

Yeva's account suggests how material objects are entangled with emotional experiences of belonging, particularly for newly arrived children navigating unfamiliar linguistic, spatial and social contexts. It can be suggested that inclusion and belonging within research and policy tend to focus on the cultural values of an institution, teachers' practices, and the allocation of funding, however, "less attention has been given to how interactions with material contexts, tools or resources can also contribute towards such a purpose" (Martin, 2019, p. 86). My research shows that listening to children's definitions and lived experiences of belonging highlights the significance of their relationships with classroom objects and school spaces. As such, these social-material dimensions of belonging are relevant to wider discourses on promoting inclusive school spaces.

Furthermore, children's narratives highlighted how belonging was constructed through multiple symbolic lines of 'difference'. Children's perspectives and experiences of linguistic, ethnic and religious identities involved a positive centring of differences to form a sense of belonging and friendships. Participants positioned themselves and others as multilingual speakers, positively framing their different migratory experiences, for example, "she [Yeva] can speak like five thousand languages!" (Rose). Like Welply (2022), language functioned as a marker of status within peer groups, and participants spoke about how they teach each other their different languages. However, belonging through difference was not always conceptualised positively. For instance, Izzy associated belonging with "fitting in" and was concerned about stories she had heard about secondary school, where older children were bullied or othered on the basis of racial differences. During the art workshops, participants had to navigate disagreements over perceived anti-Muslim utterances, and some children were othered by their peers on the basis of having limited language knowledge or religious identity. For example, Daayan was questioned by his peers if he was Muslim because he did not know Arabic. Therefore, for some, friendships and belonging at school were at odds with boundary maintenance and perceived religious and linguistic differences.

4. Conclusions

This paper is based on a study which explored children's experiences of belonging and inclusion at school. Everyday classroom objects and personal possessions emerged as agentic resources through which children navigated identity, belonging, and friendships. Children's narratives also revealed how 'sameness' and 'difference' – especially language, religion, and migration – can be sites of belonging and exclusion. My research presents a model of belonging that reflects the material, affective, and political realities of belonging in children's school lives, interlinking with notions of inclusion and perceived sameness and difference. The pedagogical implications are that schools should be attentive to material relations, the classroom spaces and ordinary objects, and how this interacts with children's experiences of belonging and self-identification. Additionally, the study highlights the need for schools to continue thinking about the necessary tools and language to celebrate differences and navigate discourses of difference, including stereotypes, otherness, and stories children hear from others. In summary, the importance of listening to the voices of younger children, including those from migrant backgrounds, cannot be overlooked in gaining novel and nuanced perspectives on belonging and understanding their experiences of schooling and living in a global world.

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THESIS BUDDY – GENERATIVE ARTIFICIAL INTELLIGENCE IN THESIS SUPERVISION

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Abstract

This paper aims to explore how generative artificial intelligence (GenAI) can support master's thesis (M.Sc.) supervision in higher education (HE), particularly by reducing repetitive guidance and improving access to institution-specific information. Specifically, it focuses on the use of a recently developed AI chatbot, *"Thesis Buddy"*, designed to supplement traditional supervision by providing continuous, on-demand support to students. Accordingly, the paper presents an exploratory study of design and early user experiences with *"Thesis Buddy"*, conducted as a Design Science Research (DSR) in a HE context. The chatbot utilizes document retrieval and large language models (LLM) to answer student queries based on internal university documents and selected external sources, while offering citations and administrative oversight. The results show that although students continue to prefer human supervision, they perceive *"Thesis Buddy"* as educationally valuable for basic, procedural, and institution-specific questions related to the thesis process. At the same time, the findings highlight challenges related to usability and the need for a clearly articulated pedagogical role. This study contributes to educational research and practice by providing design-oriented insights into how GenAI tools can be pedagogically integrated into supervision processes, supporting scalable guidance, knowledge transparency, and informed educational decision-making in HE.

Keywords: *Generative Artificial Intelligence, chatbot, thesis supervision, computer assisted learning, design science research.*

1. Introduction

Our world was disrupted in November 2022, when Open AI launched ChatGPT 3.5, the first LLM based chatbot open to general public (Lewis et al., 2025). Since then, these bots have permeated nearly all parts of our life from banking to manufacturing industries. HE is no exception. While the initial reaction in many HE organizations was detecting ways to hinder malpractice of GenAI in studies, the current view focuses more on teaching the students on ethical use of GenAI (Kangwa et al., 2025) Concurrently, the number of HE students in Finland is increasing as Finnish government has set a target of 50% of all 25–34-year-olds to hold a HE degree (OKM, 2017) and simultaneously, funding is being linked more closely to target graduation times and rates (OECD, 2025; YLE, 2025). One of the focal HE teaching processes is thesis supervision. With the growing numbers of students, the teachers need to prioritize their value-adding practices in their supervision. However, supervisors frequently repeat guidance found on universities' intranet, which seems to be hard for students to locate. For that purpose, GenAI provides possibilities to support the students with basic information retrieval, which is repetitive and time-consuming for the supervisors. To address this possibility, "*Thesis Buddy"* -chatbot was designed to provide time-independent/constant support for students. According to DSR methodology, the *"Thesis Buddy"* design was based on using document retrieval and LLMs to answer queries based on both internal and external files, offers citations, and includes an admin interface for monitoring content and users. Thus, our research question is:

> *RQ: How is an ethical and reliable GenAI-based tool created to support students' basic information retrieval for thesis project time-independently?*

2. Theoretical background

Two theoretical motivations initiated the development of *"Thesis Buddy"*. For one, it is a known fact that support on thesis process and content (e.g. methodology and structure) increase the likelihood of completing the thesis on time (Mårtensson & Söderström, 2026). This contributes to timely graduation, which is a significant part of university funding in Finland (YLE, 2025). Second, while supervisor support especially in early phases of the thesis project is seen valuable, simultaneously the students are expected to conduct the project independently and hence, the supervisor resource allocation has been reduced (Todd et al., 2004) Therefore a substitutive or supplementary support mechanism is required. Large language models (LLMs) are one possibility as they can find the required instructions and support tirelessly at any time of a day.

LLM-based GenAI does not have a ubiquitous definition. In this study, LLM refers to large scale, pre-trained, neural network based conversational systems focusing on solving tasks (Chen et al., 2020; Zhao et al., 2023). The LLM-based chatbots generate human-like responses enabling students to find relevant information and explanations from a vast range of sources (Neumann et al., 2025). Perhaps the most well-known application of LLM is ChatGPT, a state-of-the-art natural language processing model that uses deep learning techniques to analyze and generate text. It is a highly skilled chatbot created by OpenAI that uses algorithms to generate new text. In the field of education, ChatGPT has multiple uses: creating virtual tutors, answering student questions, and providing personalized learning experiences. (Su & Yang, 2023).

The second motivation in HE context is that LLMs can offer significant benefits for the students but also create risks such as hallucinations of incorrect information, plagiarism and bias (Chang et al., 2024). The thesis project requires autonomy from the students and each HE institute has unique processes and instructions in conducting the projects. To address this, a Retrieval-Augmented Generation (RAG) based system was selected to be developed, as RAG enhances the accuracy of the responses, while it understands the context better than a regular LLM (Arslan et al., 2024).

3. Methodology

"Thesis Buddy" is developed through DSR, which is a widely used methodology in creating information systems artefacts (Hevner & Malgonde, 2019). As a research methodology, DSR includes six iterative phases (Peffers et al., 2007). First, it starts with identifying the problem and showing its importance. In the second phase, the artifact is defined, i.e. what should be accomplished with it. The third phase focuses on developing the artifact, i.e. Proof of concepts (PoC). As fourth and fifth phases, it is demonstrated to the users and then evaluated. The process iterates between phases to improve the artifact. In the final sixth phase, the artifact is published in either academic or professional publications; sometimes both. (Peffers et al., 2007) Here are the *"Thesis Buddy"* -phase descriptions according to DSR:

1. The project was initiated in early 2024, when a conflict in the number of thesis supervisions per educator in a Finnish University became apparent. As a problem, it was recognized that the questions students ask and the instructions supervisors give are largely the same regardless of the thesis subject. Unfortunately, this means that the time provided for guidance for study-specific questions and helping the students to improve their scientific thinking is scarce.
2. The project started in a small team mapping the phases of masters' thesis project process, its information needs and possible sources of the required information (e.g. University instructions, methodological sources, referencing instructions, guidelines for creating a synthesis). It is worthwhile to notice that the masters' program is implemented in co-operation with two faculties, therefore *"Thesis Buddy"* is required to understand the context to some extent.
3. After mapping the process and information needs, the user requirements for "*Thesis Buddy"* were specified. The requirements were: 1. Documents are easy to upload (an administrator role for supervisors), 2. versatile document formats can be included (word, PowerPoint and pdf documents or web pages), 3. *"Thesis Buddy"* should collect the questions students ask anonymously to identify what type of information should be added.
4. Furthermore, the application of the *"Thesis Buddy"* was coded and the full source code was shared openly on GitHub (https://github.com/nasiriubat/thesis-buddy).
5. After the initial PoC-chatbot, supervisors tested it. Over 200 documents were added to the database. These documents included e.g. research methodology articles, university intranet pages for students, referencing standards, and seminal papers.
6. The PoC1 was piloted with masters' students. While the number of students is relatively small and the thesis projects take 6-8 months, we tested the system for a year and improved the system concurrently. In PoC2, the reference information was added to the responses, which helped the students to verify *"Thesis Buddy*'s" responses. From supervisor's point of view, updating the

system was easy but risk of duplicate documents became apparent as more than one supervisor had the admin. Therefore, a joint Zotero-folder was implemented to solve the problem. This was tested in PoC3, but it did not work. When references are linked to the joint Zotero folder, the pdfs are visible only to the person who uploaded the document. While most of the documents are behind a paywall, *"Thesis Buddy"* could not find them.

7. A user test with students in fall 2025 and spring 2026 was conducted. To understand, students' perceptions of the support *"Thesis Buddy"* provides, a survey was conducted.

4. Results

According to DSR, this chapter describes first the technical application of *"Thesis Buddy"* and then the students' perceptions of the use.

4.1. Technical implementation

"Thesis Buddy" was implemented as a web-based chat application hosted on a Linux server provided by CSC and running continuously using a process manager. The full source code, including the FAISS-based implementation and an administrative interface for managing data and interactions, is openly available on GitHub (https://github.com/nasiriubat/thesis-buddy).

Students can access the chat without login, while teachers use an authenticated admin interface to manage the system. Through this interface, teachers can upload and manage materials such as PDF, DOCX, text files, web pages, and manually entered text.

The system processes all materials by dividing them into smaller text segments and converting them into numerical representations using a pre-trained language model. These are stored and indexed using a similarity search method, allowing the system to retrieve relevant content efficiently. When a student asks a question, the system retrieves the most relevant segments and uses a language model to generate a response based on them. The references used are also shown to the user to improve transparency. The system supports both English and Finnish.

Teachers can monitor all questions and responses through the admin interface. Students can provide simple positive or negative feedback on answers. Questions which are not answered well can be reviewed by teachers, who can then provide a correct answer and add it to a frequently asked questions (FAQ) section. This allows the system to improve over time.

4.2. Students' perceptions of the test use of *"Thesis Buddy"*

To understand, how students find the support from the *"Thesis Buddy",* a survey was conducted. The survey was sent to the whole pilot group (n= 22). The survey responses (n=8) indicate that *"Thesis Buddy"* AI chatbot is/was still at an early stage of adoption among the participating students. The actual use remained limited: six respondents (75%) reported that they had only assessed the tool to answer the survey, whereas two respondents (25%) reported using it less than once a month. This limited exposure was also reflected in the usefulness-ratings. When evaluating with 5 star scale (5 = very useful, 1 = not useful at all), the perceived usefulness of Thesis *"Thesis Buddy"* in the master's thesis process was low to moderate (M = 2.4/5), with five of the eight respondents rating the tool at 1 or 2 and no respondent rating it at 5, indicating perceived situational usefulness rather than strong endorsement. The perceived value of *"Thesis Buddy"* as a complement to supervisor support was even lower (M = 1.9/5): six respondents rated it at 1 or 2, and again none selected 5.

Table 1. Summary of open-ended responses.

Theme	Key findings
Main uses of Thesis buddy	University instructions, thesis structure, methodology, literature review, citation practices, and personal study planning
Complementary role to thesis supervisor	Potential first-line support for basic guidance and clarifying institutional instructions.
Main shortcomings	Unclear intended use and source base, limited added value compared with other AI tools, English answers to Finnish questions, weak formatting/readability, and no direct source links
Development needs	Clearer value add proposition compared to other AI tools, improved usability, answer structure, faster and more flexible responses, and feedback mechanism for continuous improvement.
Other AI tools in use	ChatGPT (also paid versions), Claude, Copilot/Copilot Studio, Gemini, and in some cases local models for brainstorming, planning, sparring ideas, and article reading, and customized support

This suggests that students saw potential value in *"Thesis Buddy"* as **complementary support**, but not as a replacement for human supervision. Taken together, the quantitative findings suggest that *"Thesis Buddy"* had not yet established a clear role as a strongly valued support tool in the thesis process.

The open-ended responses help explain these ratings. The table 1 presents the results based on the responses concerning **five open-ended questions** concerning the use of *"Thesis Buddy"*, the added support it might provide, *"Thesis Buddy'*s" shortcomings and development needs, as well as the use alternative AI tools.

Overall, the qualitative responses indicate that while students recognized the **intended pedagogical role** of *"Thesis Buddy,"* they did not yet perceive it as competitive with or superior to widely used general-purpose AI tools.

5. Conclusions

The results of this article create new knowledge and add to the research of GenAI usage as a part of computer assisted learning in HE teaches, especially in the masters' thesis supervision context. Concluding a preliminary pilot study in a Finnish university, this article makes a couple of contributions. The main results of our research question "*How is an ethical and reliable GenAI-based tool created to support students' basic information retrieval for thesis project time-independently?"* are two-fold, revealing the following:

First, the results in this small pilot reveal, that *"Thesis Buddy"*, a RAG-based bot created to support the master thesis supervision with DSR-methodology, appears to have its strongest educational potential as a first-line support tool for basic, institution-specific questions, as intended, rather than as a substitute for supervisor expertise. Students recognized relevant use cases related to university instructions, thesis structure, methodology, literature review, and citation practices, but the tool did not yet offer sufficiently clear added value in comparison with the general-purpose AI systems they already use.

Second, the results of the survey informed the next iterations of the *"Thesis Buddy" according to the DSR-methodology:* to become a meaningful part of thesis supervision, *"Thesis Buddy"* should clarify its intended use and source base, as well as pedagogical rationale, communicate its unique value more explicitly, and further improve the usability, clarity, flexibility, and speed of its responses. A built-in feedback function could also support continuous pedagogical and technical development. After which the tool could be introduced more widely as part of the thesis guidance ecosystem, alongside traditional thesis supervision rather than being perceived as redundant.

This study contributes to the ongoing discussion on GenAI's chatbots, and particularly RAG-based system as part of computer assisted learning in the master thesis super vision context (Arslan et al., 2024; Neumann et al., 2025). Furthermore, this study contributes to GenAI's effects on master's thesis supervision in HE by offering an open-source code for further development of GenAI applications in thesis supervision. Furthermore, it contributes by expanding the understanding of student expectations and attitudes towards GenAI-enabled thesis supervision(Kangwa et al., 2025). While the students are already capable of utilizing commercial GenAI applications, they still require more specific information on where "*Thesis Buddy"* is most beneficial and how it differs from the general commercial applications. The feedback from the students helps the developer team to improve the system but also to create clearer instructions to the students. These actions together with teaching students the ethical use of GenAI can help HE organizations to achieve the targets of number of people having an HE degree (Kangwa et al., 2025; OECD, 2020)

While the student feedback is essential for further development, it needs to be emphasized that the number of respondents was small, which creates a significant limitation to this study. Moreover, the testing time has been short, and the application is still under development. Keeping these in mind, further research is required. Namely, the testing and development in this specific masters´ program needs to be continued but also more pilots in different context should be conducted to confirm our findings.

"Thesis Buddy" does, however, offer potential to revise the thesis supervision practices.

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CSI-POM: EMPOWERING OCEAN LITERACY THROUGH MARINE RESEARCH AND MONITORING

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Abstract

In our Ocean Literacy activities, we applied two modern research systems, CSI-POM and its second stage, CSI-POM2, to involve, first teachers and then youth in educational activities. In this presentation we focus on a CSI-POM2 system. The CSI-POM2 system was designed to monitor and forecast the state of the southern Baltic environment and its changing environmental conditions, thereby providing a modern tool for effective environmental management in the Polish maritime economy and as well as for protecting people and the environment. Therefore, the primary purpose of the system is to provide scientific information and support decision making, while we used its features for educational activities. In late fall 2024, we had run two day-long, in-person workshops entitled: Using CSI-POM2 tools in modern ocean education. Both workshops gathered a total of 24 participants representing 18 various educational institutions, both formal and non-formal. Then, in late spring 2025, we run a webinar for school teachers, which gathered over 25 participants from different institutions. During these events, we discussed the opportunities and challenges facing the education in the context of using innovative tools such as those developed within the project. According to the SWOT analysis, based on the outcomes of the events, ease of use, free access, and interactive data presentations are the strengths of CSI-POM tools. Thus, they can very well support activities dedicated to increase of ecological awareness and in ocean educational activities. Therefore, we prepared educational packages, which we have been successfully using in educational activities since the beginning of 2026, with a total of over 90 educators who were introduced to the educational package of the system. During the presentation, we briefly show the system features and examples of lesson plans based on the system tools.

Keywords: *Ocean Literacy, environmental education, public engagement, oceanographic data, environmental monitoring.*

1. Introduction

The world ocean covers over 70% of our planet's surface and plays a key role in creating and mitigating climate, sustaining biodiversity, and providing means for supporting all life. Despite this crucial role, ocean is not very well understood and common knowledge about the ocean is still very limited and fragmented. The general level of ocean literacy, a concept that refers to an understanding of how the ocean functions within Earth's systems, how human activities affect marine ecosystems, and how individuals can make informed choices to protect ocean health, is still low.

Environmental adverse pressures, mainly related to climate change, marine pollution, and marine biodiversity loss continue to increase (e.g., O'Hara and Halpern 2022). Therefore, promoting ocean literacy is becoming real requirement for all parties, including those involved in marine research and monitoring, elements which may play a central to this effort. In order to connect people with the ocean, society needs scientific evidence, which supports deeper ocean ecosystem understanding and guide decision-making, hence foster greater awareness and responsibility toward the ocean (Kennedy 2026).

While we observe continuous changes in education of any form and the growing role of technology in teaching and learning, the concept of ocean literacy is directly embedded in the goals of the UN Ocean Decade, which puts stress on a shift from more old-fashioned, theoretical understanding to more participatory, active and responsible citizen. Thus, such approaches like systems thinking and interdisciplinary learning require modern curricula, which reach beyond individual subjects. Themes such as the ocean's influence on climate change, economic aspects, human health, and social equity need to be addressed along with ocean natural sciences, bridging STEM and the social sciences, fostering a holistic understanding of ocean-related challenges and seek more effectively for solutions (Kennedy 2026).

However, raw data themselves, without analyses and interpretation, carry no precise information, still they are crucial for creating knowledge (Serban and Luan, 2002; Zins, 2007), which results from understanding of information, and thus it is related to acquiring and remembering a bulk of facts and ability to analyze information and hence solve problems.

This paper presents an example of how marine research and monitoring system contribute to advancing ocean literacy through knowledge co-creation, education and collaboration with diverse citizen groups. In our Ocean Literacy activities, we applied a research and monitoring system, CSI-POM2 to involve first teachers and then youth in educational activities.

2. Barriers and opportunities in advancing ocean literacy

We see a lot of positive actions and thus progress in terms of ocean awareness among youth, however, barriers are still observed (Zielinski et al., 2021). Science provides information in a very hermetic and technical thus inaccessible to non-experts form, while most education systems still do not recognize ocean science as an important theme for school curricula, hence there is lack of proper resources or training to integrate ocean science into the education (Shellock et al., 2024). Additionally, limited access to technology in many regions, language barriers and cultural differences still set challenges for effective outreach efforts (Fauville, 2017). Formal education is resistant for fast changes and introduction of new approaches, and many formal educators still seldom search for direct research based sources, instead being faithful to the text books and simply passing information embedded in those (Donert, 2018; Kopke et al., 2019; Kotynska-Zielinska et al., 2020). As a result, students often lack a chance to generate knowledge themselves, not to mention data collection, thus miss the process of conversion of data into precise information, without the remaining knowledge parts, i.e. experience, context, application (Donert, 2018; Fauville et al., 2019; Fischer et al., 2019).

Ocean science is fully inter and multidisciplinary, since it integrates natural science disciplines as well as social sciences. The need for integrative approach requires from the society to understand that the ocean is built of interconnected systems, showing a huge variety of environmental challenges. A real boom in advancing of the ocean monitoring technologies opens the doors for the exploration and understanding of the ocean. New and innovative tools not only boost an increase in knowledge but also provide interesting visual and research data-based modules for education. These may include, interactive maps, live ocean observations with UUVs, bringing the ocean close to students regardless in which part of the globe they are.

Open-access ocean data hubs make ocean data and information open and free to public, including educators, students, policymakers, and citizens, thus any stakeholder can be in direct contact with real ocean data and information, which strengthens trust in science and thus supports ocean literacy to enable non-scientists to see patterns themselves, draw their own conclusions and thus, transfer ocean literacy from passive awareness to the process of active analysis. Ocean monitoring tasks involve ongoing and/or repeated observations over a period of time to observe and report changes in ocean conditions, ecosystems and it provides data necessary for understanding trends and system responses.

Joint actions and networks of scientists, teachers and educators help to co-create educational content, which is in line with philosophy of the frameworks of the United Nations Decade of Ocean Science for Sustainable Development (2021–2030), which prioritizes equal access to knowledge and capacity building, accelerating global efforts to foster ocean literacy.

3. Methodology

The CSI-POM2 system was designed to monitor and forecast the state of the southern Baltic and its environmental conditions, thereby providing a modern tool for effective environmental management in the Polish maritime economy and as well as for protecting people and the environment. Therefore, the primary purpose of the system is to provide scientific information and support decision making.

As a result of a number of consultations with various stakeholders, we decided to use its features for educational activities. In fall 2024, we invited educators of both formal and non-formal education and run two day-long workshops entitled: *Using CSI-POM2 tools in modern ocean education*. Both workshops gathered a total of 24 participants representing 18 various educational institutions. Then, in spring 2025, we run a webinar for school teachers, which involved over 25 participants from different institutions. During these events, participants, in groups, discussed opportunities and challenges facing education while using innovative tools such as those developed within the CSI-POM2 project.

According to the SWOT analysis, based on the outcomes of those events, ease of use, free access, and interactive data presentations are the major strengths of CSI-POM2 tools (Table 1).

Table 1. Selected strengths and weaknesses of the CSI-POM system in relation to education.

Strengths	Weaknesess
1. **Interdisciplinarity and versatility:** The wealth of available information enables interdisciplinary project activities, supporting diverse fields of science, practice, and education. 2. **Ease of interpretation of results and access to educational materials:** Users can easily interpret modeling results while also having access to basic educational information. 3. **Vortex parameter – attractive visualization:** Generated maps are visually attractive, enhancing their usability and educational value. 4. **Compatibility with current educational topics:** The project aligns with a modern approach to formal education, promoting community-oriented learning. 5. **Intuitive interface and ease of use:** Simple and intuitive interface allows for easy interpretation of results, making the model user-friendly, especially for educational purposes.	1. **Inability to generate PDFs:** The model only allows for saving results in JPEG format. 2. **Lack of targeted educational materials:** There is a lack of educational packages tailored to the needs of different audiences, such as students and teachers. 3. **Lack of tutorials :** There are no educational resources explaining the use of individual parameters, interpretation of results, or lesson examples. 4. **Limited information in the "info" section:** The information available in the "info" section and its interpretation is limited only to the information contained in the button. A guide, tutorial, or sample lesson is needed. 5. **Insufficient project promotion:** There is lack of information on the portal's innovative nature, e.g., regarding the high-resolution model, which should be the basis for its promotion.

The above strengths and weaknesses clearly show that the system could/would be a useful toolbox for educational activities, mainly those oriented towards the Baltic Sea but also can very well support activities dedicated to increase of general environmental awareness. To address these apparent needs we prepared educational packages, which we have been successfully using in educational activities since the beginning of 2026, with a total of over 180 educators and teachers who are to be introduced to the educational package of the system by end of May 2026.

4. The CSI-POM2 based educational actions

Integrating ocean science into educational activities supports students with scientific literacy and ecological awareness. Typically, research institutions collaborate with educators to develop age-appropriate, educational materials. Therefore, using the CSI-POM2 products we selected the modules, which can serve to support formal and non-formal education, transforming scientific data into accessible knowledge and create clear message.

We created lessons based on real data collection system features and focused on analyzing changes in e.g. sea surface temperature, salinity or tracking blue algae blooms. We adapted an interactive workshop scheme for students of different ages. The workshops title is: *Fishing from an ocean of data to foster the development of a knowledgeable and sustainability friendly society* and its goal is to explore the features of the CSI-POM2 system in supporting community led action on sustainability, climate action, and community resilience through engagement and outreach. Co-designed in collaboration with European partners and community representatives, the workshop explores opportunities and challenges in communication of scientific information to school students. The workshop procedure is a “live” version (© I live by the Sea Ocean Action) and it is also suitable for an online meeting.

A series of short introductions from the panel (including live links and/or recorded video messages from community groups) precede group work on creation of dedicated sustainability related actions with use of the CSI-POM2 data base and interactive features. During the workshop participants, in groups, use their common knowledge to create effective means/actions for transfer of science-based information with reference to information they can obtain from the CSI-POM2 system. The participants work out the following:

1. First, they search through the CSI-POM2 system to choose the theme they would like to work on, e.g. sea surface temperature changes over a selected period of time.
2. Then, participants decide on who they want to address their information and what format (infographic, brief, video, presentation, etc.) will be most effective?
3. Participants make short analyses of the data set and then create the message to their dedicated group of information recipients.

This can be done during the workshop (short version) or a scheme for the project is created and then each group takes home their work and returns to us with a final product. Meanwhile, our team of researchers is available for discussions, if needed. A typical workshop lasts around 3 hours and 30 minutes and the plan is as follows:

1. Participants sit at 3-5 tables of up to 5 per table. (c. 5 min).
2. Participants divide roles, e.g. data researcher, communication expert, etc. (c. 10 min).
3. Participants get the first part of the Baltic general knowledge questionnaire. (c. 10 min).
4. Short introduction, short lectures about ocean, Baltic, knowledge, data collection. (20 min).
5. Work in groups, starting with the theme selection. (60 min).
6. Break. (20 min).
7. Groups present their projects for max. 15 minutes, including general discussion. (c. 60 min).
8. Participants get the final question (*How does ocean influence you?*). (10 min).
9. Summary by organizers. (10 min).

Acknowledging that each group varies, we have flexibility to modify the structure of the workshop, however, using system products as a basis for the development of the project by each group.

Another educational block involves a set of educational materials, namely lesson plans for educators and students. Each lesson set consists of 2-3 short presentations tailored to the theme, e.g. general info on the coastal area features (e.g. sea breeze), Baltic Sea and the Gulf of Gdansk, and a short video about the CSI-POM2 system from an educational perspective. Then, we provide lesson plan(s) for educators, including full description of the activities, materials and the same package is provided for students (tailored for their needs). A typical lesson plan is as follows (e.g. Sea breeze):

1. Lesson theme: *What is sea breeze?*
2. General lesson objectives: Student knows that breezes occur in the coastal area of the sea, in what direction they blow depending on the time of day, and why the direction changes with the time of day/year.
3. Work methods: Short talk, Presentation, Experiment.
4. Teaching tools: Worksheets plus articles needed for the experiment: 2 metal bowls, Sand, Ice, Candle and a lighter.
5. Lesson plan:

Introduction: Educator explains the characteristics of the coastal zone. Students try to explain the differences between the daytime (heating) and nighttime (heat release).

6. Proper lesson:

Characteristics of winds (speed, direction, strength). The sun as a heat source. Define the concept of a sea breeze and illustrate the phenomenon with images.

Experiment – The experiment requires two metal pots/bowls, ice, sand, and a candle. The experiment should be conducted with the windows closed and be draft-free.

Use a lit candle to check for drafts. Then, pour sand into one container and heat it in an oven/warmer at approximately 300°C (572°F) for up to 8 minutes. Fill the second container with ice and place both containers side by side. Place the lit candle between the containers and then extinguish it. Observe the direction in which the smoke travels.

7. Summary – students respond to questions:

1. Does the sea breeze occur in every coastal area?
2. Is the sea breeze only a local phenomenon?
3. Does the sea breeze occur only on a daily basis, or also on a monthly scale?

8. Formulation of project work/homework: Describe the potential consequences of breeze circulation for coastal areas. Consider the problem of pollutant transfer. Consider the issue of breeze circulation on a monthly scale (monsoons).

5. Conclusions

Fostering and strengthening ocean literacy is a joint challenge, which aims at bridging science, monitoring, education, policy, and community engagement (Shellock et al., 2024). Marine research and monitoring systems provide data, information, hence knowledge that deepens understanding of ocean ecosystems, and facilitates observations of ecosystem changes as well as can relate scientific insights in understandable realities. Both of these “legs” support or should support education, evidence-based policy, and promote and strengthen community engagement in ocean stewardship.

Applying ocean literacy principles fosters much closer connection between abstract concept of the ocean into a tangible, common responsibility, supporting individual, daily actions with global and far reaching consequences (Fauville, 2017). Therefore, societies must depend on science based knowledge to cultivate understanding, facilitate dialogue, and support all citizens in their choices and further acts.

It is researchers co-responsibility to translate their research results to understandable information for societies and to co-create knowledge together with citizens, who e.g. can be involved in the process of creation ocean study models (Fauville, 2017). Our application of the CSI-POM2 Baltic monitoring system for creating educational materials and workshop ideas fits in very well into the idea of fostering Ocean Literacy principles among both local and global society.

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BALANCING TEACHING AND RESEARCH: INTEGRATION OF SCIENTIFIC PROJECT OUTCOMES INTO UNIVERSITY CURRICULA

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Abstract

Balancing teaching and research is a growing challenge in engineering education, particularly in the context of rapid technological development and the increasing importance of applied skills. This paper examines how research activities conducted by university teachers can be effectively integrated into undergraduate teaching without compromising curriculum structure. The study adopts a qualitative approach based on the analysis of teaching practices, student outputs, and informal feedback within electrical engineering programs. The findings indicate that the most effective forms of student engagement are those embedded within existing course structures, particularly seminar assignments, final-year projects, and field-based learning activities. These approaches enable students to work on real-world problems while developing practical and interdisciplinary competencies. The results also highlight mutual benefits: students gain improved employability and exposure to modern technologies, while teachers enhance the relevance of their teaching and extend student work into research outputs. The insights obtained in this study provide a basis for the systematic integration of research and teaching in future curricula and will be further applied within the ongoing ELENDRON project, which focuses on AI-supported monitoring of power infrastructure.

Keywords: *Pedagogical innovation, AI in education, student competencies, sustainable technology, Industry 4.0.*

1. Introduction

The role of university teachers has significantly evolved in recent years, extending beyond traditional teaching responsibilities to include active participation in scientific research and continuous adaptation to rapid technological advancements. In engineering education in particular, this dual role creates both challenges and opportunities, especially in the context of integrating emerging technologies such as artificial intelligence (AI) into the learning process.

One of the key challenges is how to effectively connect research activities with teaching practice in a way that enhances student learning without compromising curriculum structure or educational quality. While research-based and project-based learning approaches are widely recognized, their practical implementation often depends on individual initiatives and is not always systematically embedded in study programs.

Recent developments associated with Education 4.0 and Industry 4.0 have emphasized the need for higher education institutions to redesign learning environments and develop both technical and transversal competencies, including critical thinking, adaptability, collaboration, and data-driven decision-making. Emerging technologies such as AI, IoT, simulation platforms, and adaptive learning systems are increasingly recognized as important enablers of personalized and practice-oriented learning experiences in engineering education. [Pinto et al., 2024; Khupe et al., 2026; Azofeifa et al., 2024]

However, several studies indicate that the pedagogical integration of these technologies remains fragmented and often limited to supportive or instrumental applications rather than being systematically embedded into teaching and learning processes. Similar observations have been reported in both engineering and translation education, where digital tools are frequently used as auxiliary resources instead of being integrated into authentic learning activities and professional problem-solving contexts. [Fernández Cerero et al., 2026; García-Santiago & Díaz-Millón, 2024] Although previous studies show that AI-supported and simulation-based learning approaches can improve practical skills, systems thinking, and Industry 4.0 competencies, there is still limited evidence regarding sustainable models that effectively

connect technological innovation, research activities, and measurable educational outcomes within university teaching practice. [Pacheco-Velazquez et al., 2024; Gabrovšek & Rihtaršič, 2025]

In practice, students are often exposed to theoretical concepts with limited connection to real-world applications, while research activities remain insufficiently integrated into teaching. This gap highlights the need for structured approaches that enable meaningful student participation in ongoing research, particularly in technical fields where hands-on experience and interdisciplinary skills are essential.

The aim of this paper is to identify effective models of student involvement in research-oriented activities and to evaluate their benefits for both students and teachers. In particular, the paper seeks to answer the following research questions:

- RQ1: What are the most effective ways of involving students in research projects conducted by university teachers?
- RQ2: What are the key benefits of such involvement for students and for teachers?

The remainder of the paper is structured as follows. Following this introductory and theoretical background section, the next sections present the methodology and an analysis of current teaching practices. The results are then discussed with a particular focus on transferable insights and future implementation within new curricula, followed by concluding remarks.

2. Methodology

This study adopts a qualitative research approach based on the analysis of existing teaching practices and experiences in integrating research activities into undergraduate electrical engineering education. It does not rely on large-scale quantitative data or formal surveys; instead, it focuses on an in-depth analysis of practical experiences within a specific educational context. While this limits the generalizability of the findings, it allows for the identification of context-sensitive practices and the formulation of transferable recommendations.

The analysis draws on multiple sources: (i) teaching experience across several courses, (ii) student outputs, including bachelor theses and term papers, and (iii) informal student feedback, particularly following field-based activities.

Based on the experiences analyzed, a framework is proposed for a more systematic integration of research activities into future curricula, including planned implementation within an ongoing research project (ELENDRON). This advanced component is intended to bridge existing practices with structured, scalable models of inquiry-based teaching.

3. Analysis of current practices in research - teaching integration

This section presents an analysis of current practices in integrating research activities into teaching, focusing on forms of student engagement and their outcomes.

3.1. Teaching context and forms of student engagement

The integration of research activities into teaching is analyzed in the context of the undergraduate professional study of electrical engineering at the University North (Varaždin, Croatia). Student engagement is carried out through several complementary forms. The most common approach involves seminar assignments within elective courses, where students investigate specific technical problems related to current research topics. In addition, students are encouraged to produce final-year undergraduate theses aligned with real-world applications and new technologies.

Final year students attend several courses taught by authors, including Electronic Circuits, Digital Electronics, Automation of Machines and Devices, PLC Control Systems, and Electromotive Drives. Of particular importance is the elective course Power Electronics Devices, which focuses on the application of power electronics in systems based on renewable energy sources (RES). This course is chosen by the majority of students and currently serves as the primary entry point for integrating research-related topics into teaching. The elective format allows greater flexibility in adapting content to student interests and research-related activities.

Another key element of this approach is the possibility of organizing field learning activities, such as visits to industrial plants and renewable energy plants. These visits provide students with direct insight into real operating systems, including critical monitoring and maintenance points. In particular, the demonstration of real-time monitoring and remote control via mobile devices introduces students to the concepts of digital management and the role of data-driven decision-making, which aligns with modern AI-based approaches to energy system management. Such experiences bridge the gap between theoretical knowledge and practical application, while at the same time serving as a strong motivational factor for further student engagement.

Figure 1. Student visit to photovoltaic power plants. Left: photovoltaic panels mounted on a solar tracking system that follows the sun to increase energy production. Right: students and the teacher observing real-time monitoring and control of the power plant via a mobile interface, demonstrating remote management and data-driven operation.

After these field visits, a noticeable increase in student interest in renewable energy topics, especially related to solar energy systems, was observed. This often results in the selection of related topics for seminar papers and final undergraduate theses.

3.2. Student outputs and measurable outcomes

The effectiveness of the described approach is reflected in the analysis of student results and subsequent research activities. A significant number of final theses were developed based on practical experiences gained through field visits and laboratory work. An analysis of 218 defended theses over the past ten years shows that 28 were related to renewable energy, including 18 specifically focused on solar systems.

One example is a student project focused on developing a functional model of a photovoltaic system with a solar energy tracking mechanism (Solar Power Plant with Solar Tracker), directly inspired by a field visit to a solar power plant [Juričan, 2018]. In another case, the installation of a small off-grid photovoltaic system at a university enabled two students to conduct equipment testing, resulting in two separate final year theses [Kornet, 2017; Pozder, 2018]. These works were later partly used as a basis for further research, leading to several conference publications co-authored by faculty members [Havaš et al., 2023; Horvat et al., 2023; Srpak et al., 2017].

Furthermore, in several cases, high-quality student works related to solar energy systems, including grid impact analyses at the connection point [Pajan, 2015] and practical applications of photovoltaic systems in real buildings [Stijačić, 2014], were extended by collaboration with faculty members, resulting in co-authored scientific publications [Srpak et al., 2014; Srpak & Pajan, 2016]. This shows that student engagement in research-oriented activities can contribute not only to their learning outcomes, but also to the research productivity of academic staff.

4. Discussion

The analysis confirms that research-based and project-based learning can be effectively integrated into undergraduate engineering education through flexible mechanisms. Activities such as fieldwork and project assignments act as strong motivational drivers, particularly in technical disciplines. In response to RQ1, the most effective forms of engagement are those embedded in existing course structures, especially term papers and final theses aligned with ongoing research.

In relation to RQ2, the results highlight clear benefits for both students and faculty. Students acquire practical and interdisciplinary competencies, including exposure to modern technologies, real-world system operation, and data-driven decision-making. This improves labor market readiness and aligns student competencies with Industry 4.0 requirements. At the same time, teachers benefit from the increased relevance of teaching and the potential to extend student work to research outputs, including co-authored publications.

However, the findings also point to several challenges. Student engagement in research activities is often informal and dependent on individual motivation and prior knowledge. In addition, the lack of systematic monitoring of learning outcomes makes it difficult to quantitatively assess the impact of these approaches. This suggests the need for more structured frameworks that would enable consistent implementation and evaluation.

Based on the practices observed, several recommendations can be identified. These include aligning student assignments with real-world research problems, introducing fieldwork as a standard component of courses where possible, and allowing flexibility in curriculum design to accommodate new technologies. Furthermore, the selection of students for more advanced engagement should take into account prior competencies, particularly in areas such as data analysis and the application of artificial intelligence.

These insights provide the basis for the future development of a more systematic model for integrating research and teaching. This model will be implemented and further evaluated within the ongoing ELENDRON project, which focuses on the application of artificial intelligence and unmanned aerial vehicles (UAVs) for monitoring and maintaining Croatia's electrical infrastructure. As the project is currently in its early implementation phase, it provides an opportunity to further evaluate and extend the approaches presented in this study.

5. Conclusion

This paper examined the integration of research activities into undergraduate electrical engineering education, focusing on practical teaching approaches and student engagement in real-world contexts.

The findings show that effective student involvement can be achieved through existing course structures, particularly via seminar assignments, final-year projects, and field-based learning. These approaches support the development of practical and interdisciplinary competencies while simultaneously increasing student motivation and participation in applied learning activities. At the same time, they create opportunities for extending student work into research outputs, contributing to academic productivity.

Although based on a qualitative and context-specific analysis, the results highlight a practical and transferable approach to research–teaching integration that does not require major curricular changes.

Future work will focus on developing a structured framework for monitoring learning outcomes and evaluating the long-term impact of this approach, particularly within ongoing research projects.

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CO-CREATING LEARNING SPACES: STUDENT AGENCY AND COLLABORATION IN THE METAVERSE

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Abstract

The objective of our study was to examine whether metaverse-based learning environments, when co-created by students, can enhance collaborative learning experiences in higher education. Specifically, the research investigated how co-creation influences engagement, social interaction, and collaborative effectiveness in virtual learning spaces. The study was implemented using the FrameVR platform across multiple higher education programmes. Twenty students used the platform to support group assignments and peer mentoring activities and eight of them were actively involved in co-creating their virtual environments. A mixed-methods research design was employed to evaluate the intervention. Qualitative data were analysed using thematic coding, while survey data were examined for usage and engagement patterns. Behavioural mapping of recorded sessions was used to analyse movement, interaction density, and patterns of collaboration. The results indicate that metaverse-based collaboration supported higher levels of engagement and interaction compared to typical videoconferencing practices. Embodied movement, persistent avatars, and interactive tools such as shared whiteboards and screens sustained participation. Co-creation practices were associated with increased student ownership, psychological safety, and willingness to contribute. The findings suggest that integrating co-creation into immersive learning design can enhance collaborative effectiveness and student wellbeing. The paper concludes with practical implications for educators and designers and identifies the need for longitudinal and cross-institutional research to assess sustainability and transferability.

Keywords: *Metaverse-based learning, student co-creation, collaborative learning, immersive learning environments, higher education.*

1. Introduction

As higher education shifts toward hybrid and online models, fostering meaningful student collaboration has become a significant challenge. Traditional platforms like Zoom and Microsoft Teams, while effective for lectures and one-to-one discussions, often fail to replicate the dynamic, informal interactions of in-person teamwork. This leads to disengagement, weaker social connections, and a reduced sense of togetherness, as students report feeling disconnected (Bergdahl, 2022).

The metaverse, a network of persistent, interactive 3D worlds, has emerged as a potential solution. Unlike conventional video calls, the metaverse allows users to interact via avatars, manipulate shared digital objects, and inhabit immersive spaces (Ritterbusch & Teichmann, 2023). Its unique affordances include spatial presence (a sense of "being there"), embodied interaction (non-verbal communication through gestures and proxemics), and student agency (co-designing virtual workspaces to boost engagement). These features are grounded in theoretical frameworks such as Social Presence Theory, Collaborative Learning Theory, Embodied Cognition, Media Richness Theory, and Flow Theory, all of which suggest that immersive environments, such as the metaverse, can enhance social connection, shared understanding, and motivation.

Practical applications of the metaverse in education are diversifying, including immersive ecosystem simulations, gamified learning platforms, and persistent virtual classrooms that foster a stronger sense of community than traditional videoconferencing (Jovanovic & Milosavljevic, 2022; Mistretta, 2022; Han et al., 2023). However, a significant research gap remains: most empirical studies have focused on technical feasibility or using the metaverse for lectures and simulations, rather than systematically investigating how its unique affordances enhance student collaboration specifically. Moreover, most

implementations are top-down, lacking participatory, co-creative approaches where learners help design their own collaborative spaces.

To address this gap, the presented work investigates whether the metaverse's affordances translate into measurable gains in collaboration, engagement, and wellbeing. It offers three key contributions: (1) a participatory design framework where students co-created their virtual workspaces with training and support; (2) empirical evidence from analysis of 14 recorded metaverse team meetings (~7 hours), survey data (n=54), and semi-structured interviews (n=9) addressing whether collaboration is effective in the metaverse and how students perceive engagement, wellbeing, and connection; and (3) practical insights and actionable recommendations for educators and developers. By combining student co-creation with mixed-methods analysis, the research bridges the gap between theoretical promise and practical application. The aim is to provide a balanced, evidence-based account to inform richer, more sustainable, and student-centred models of immersive learning.

2. Methodology

We employed a mixed-methods approach to investigate student collaboration in co-created metaverse environments, combining qualitative data (semi-structured interviews and behavioural observations) with quantitative data (post-surveys measuring engagement metrics such as collaboration frequency and self-reported satisfaction). This methodology is applied across three distinct academic contexts: undergraduate, postgraduate, and extracurricular settings, each involving student co-design of virtual spaces tailored to their collaborative needs.

2.1. Participants

The study involved two key participant groups. First, the co-creators: eight paid student interns who designed metaverse spaces and conducted data collection and analysis. Six of these formed or joined a metaverse team and completed surveys and interviews. Second, the teammates: fourteen additional students who joined the four metaverse-using teams, bringing the total collaborating students to twenty (six interns plus fourteen teammates). This dual structure enabled insights into both the design process (co-creation) and implementation (student usage). Ethics approval was obtained, and all participants provided informed consent.

The participants came from three programmes. The first is a first-year undergraduate Chemistry programme, where teams of five students create a sustainability-themed poster and presentation. The second is a Master's module in Sustainable Management, involving client-based group projects in teams of four. The third is the "Fresher to Thriver" (F2T) peer-mentoring initiative, where six senior undergraduates mentor junior peers across London and China campuses. Ultimately, four coursework teams adopted the metaverse: Teams A and B (two five-student Chemistry groups), Team C (a four-student Business and Management group), and Team D (a six-student F2T mentoring group).

2.2. Platform selection: FrameVR

FrameVR was chosen as the metaverse platform due to its balance of accessibility, flexibility, and user-centric design (Pazakou & Mystakidis, 2025). Key advantages included: accessibility (runs on standard laptops and desktops with no headset or installation required), ease of use (low learning curve with drag-and-drop tools and no coding needed), customisation (teams could add branding, shared displays, and adjustable layouts), and avatar personalisation (students customised appearances to boost engagement and representation). These features supported a collaborative, equitable, and creatively empowering environment.

2.3. Data collection and analysis

Approximately seven hours of video material (14 recorded meetings) and nine semi-structured interviews captured student behaviours and perceptions. Recordings were distributed across teams (Team A: 5, B: 3, C: 3, D: 3), with occasional technical issues. The interview sample comprised six co-creators and three teammates, all voluntary. All six interns who were part of a metaverse team agreed to be interviewed, while only three teammates chose to participate.

In parallel, 54 post-session surveys were completed by 19 participants (several contributing multiple times). Surveys combined Likert-scale items with open-ended questions to assess engagement and satisfaction.

Analysis proceeded in three stages. First, thematic coding of interview transcripts was conducted in NVivo. Second, emergent themes were compared with survey patterns to identify convergence and contrast. Third, behavioural analysis of video recordings focused on movement, gestures, and interaction in relation to spatial characteristics. Interviews provided depth, surveys provided breadth, and videos

provided behavioural corroboration, enabling triangulation of not only whether metaverse collaboration was effective but also how and why.

An initial coding framework was developed collaboratively by researchers and all eight interns to establish a shared analytical foundation. Interview transcripts were first coded independently by two student interns to maximise thematic coverage, after which researchers met to resolve inconsistencies and refine the thematic structure. This rigorous approach ensured that findings were grounded in both student perspectives and systematic analysis.

3. Results

3.1. The metaverse spaces

Four distinct metaverse spaces were co-created by student interns, each reflecting diverse design preferences. Space 1 (Team A, Chemistry undergraduates) was a minimalist study lounge featuring whiteboards and a green plant echoing the sustainability theme (see Figure 1). Space 2 (Team B, Chemistry) adopted a corporate, functional style with labelled zones including a presentation area, feedback areas, and a resource hub (see Figure 2). Space 3 (Team C, Master's students) was a modern multi-level conference hub with open meeting areas and private pods (see Figure 3). Space 4 (Team D, mentors) featured an intimate, personalised design with dark tones, university branding, Christmas decorations, and outdoor elements like water and trees (see Figure 4).

Interns expressed strong enthusiasm for the co-creation process, motivated by novelty and the potential to transform online collaboration. They contrasted the metaverse favourably with pandemic-era Zoom fatigue, finding the building process accessible, enjoyable, and versatile for various academic needs.

Figure 1. Space 1, used by Team A: a minimalist study lounge.

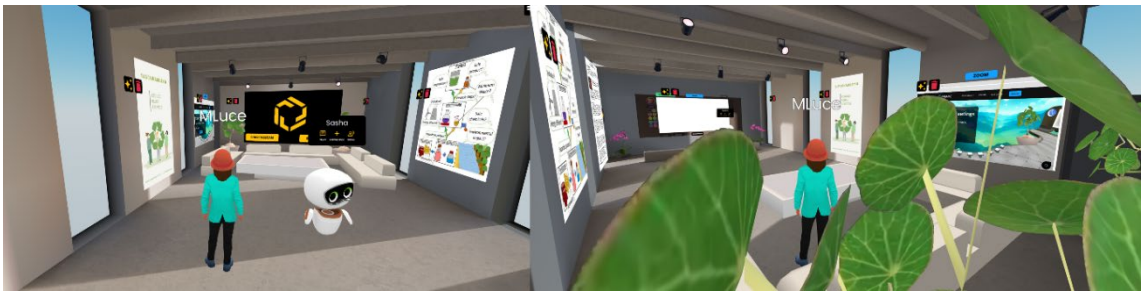


Figure 2. Space 1, used by Team A: a functional large convention centre.

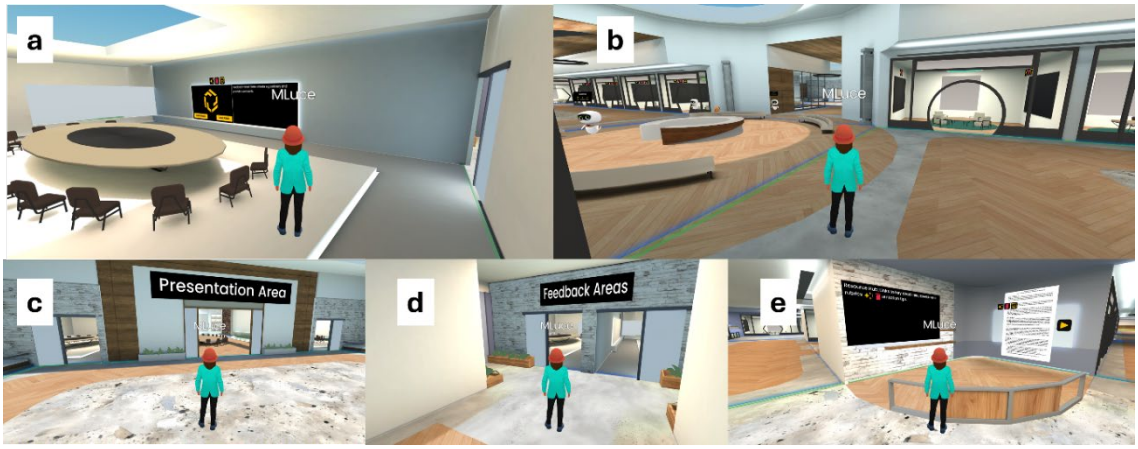


Figure 3. Space 3, used by Team C: a large conference hub.

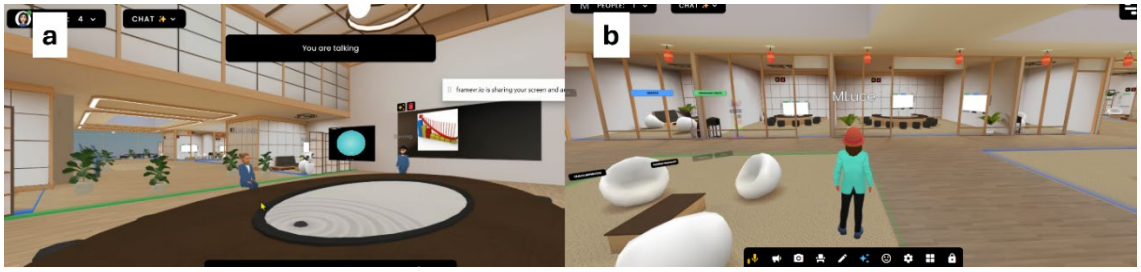
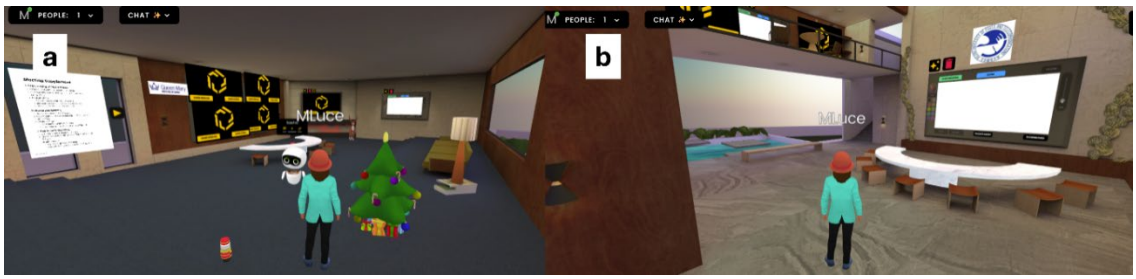


Figure 4. Space 4, used by Team D: a cozy multi-level meeting complex.



3.2. Empirical evidence on collaboration

3.2.1. Movement, presence, and atmosphere. Participants made frequent references to movement (52 references) and co-presence (40). Walking with avatars and exploring spaces transformed meetings into dynamic experiences, reducing the passivity of conventional video calls. Behavioural analysis showed that compact layouts (e.g., Team A) encouraged mobility, while expansive or partitioned spaces sometimes reduced movement and left peripheral zones unused. The atmosphere was consistently described as relaxed yet productive (31 references), with informal moments, laughter about avatars, small talk, and light games, setting a positive tone before focused work. This balance relieved stress, encouraged openness, and strengthened teamwork.

3.2.2. Tools, features, and avatars. Collaboration was closely linked to specific tools. Document sharing (23 references), screen sharing (20), and whiteboards (22) streamlined explanations and enabled interactive brainstorming, including playful uses like tic-tac-toe. Audio zones (23) were valued for potential subgroup work, though video data showed teams usually remained together. Avatars (50 references) were particularly salient, allowing professional representation or playful experimentation. Teams varied in their approach: Team A created avatars resembling their real selves emphasising authenticity, while others used preset options.

3.2.3. Comparisons with other platforms. Participants described the metaverse as a "middle ground", less formal than face-to-face yet far more engaging than Zoom or Teams, which were seen as "boring" or "impersonal." The persistence of virtual spaces (10 references) enabled continuity, though without moderation, distractions like spamming emotes could occur.

3.3. Survey evidence and team-level patterns

Out of 54 survey responses, 96% rated their experience as "good" or "very good," with no negative evaluations. Team-level patterns emerged clearly. Team A (minimalist design) reported the widest range of collaborative uses, team building, brainstorming, and exploration, with consistently positive ratings. Team B (corporate/functional) focused narrowly on presentation tasks and reported weaker engagement. Team C (modern conference hub) enabled multiple activities but produced mixed ratings. Team D (intimate/personalised) emphasised bonding, brainstorming, and exploration. These patterns suggest that minimalist, flexible designs may better support creativity and engagement, while overly formal or expansive spaces can limit interaction.

4. Conclusion and recommendations

In summary, participants found the metaverse highly effective. Screen sharing, whiteboards, and document sharing made teamwork more dynamic than conventional platforms. The same features enhanced engagement and inclusion. Informal interactions, avatar customisation, and playful rituals fostered bonding, reduced awkwardness, and motivated participation. Productivity arose not despite but because of the metaverse's socially rich, playful dynamics.

The findings align with and extend several theoretical frameworks. Supporting Social Presence Theory, avatars, shared spaces, and embodied gestures heightened perceptions of "being there together," addressing the fragmented interaction common to videoconferencing. From Collaborative Learning Theory, the metaverse enabled not just dialogue but shared practice, manipulating documents, brainstorming on whiteboards, and building trust through playful elements. Embodied cognition perspectives highlight how movement and gesture supported focus, while Media Richness Theory explains why the metaverse felt richer than Zoom through combined verbal, non-verbal, and spatial cues. Experiences of immersion and playfulness resonate with Flow Theory, where enjoyment sustained motivation.

Empirically, this study extends prior research that focused mainly on lectures or simulations, offering systematic analysis of teamwork effectiveness and wellbeing. Finally, the findings underscore the value of participatory, co-created environments. Students who configured their own spaces, experimented with avatars, and embedded bonding rituals demonstrated that agency in shaping environments was itself a driver of effectiveness. In line with socio-constructivist principles, productivity emerged from playful, socially rich dynamics, with informal interaction forming the basis for cohesion and teamwork.

Practical recommendations for educators and designers include: blending structure with informality (combining focused tasks with playful rituals), selecting and moderating features (prioritising whiteboards and avatars while managing distractions), facilitating with balance, empowering student agency through co-creation, and ensuring equity and access. Future research should pursue comparative and longitudinal studies examining how specific affordances shape collaboration and how immersive environments can be sustainably integrated into hybrid ecosystems.

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DRIVERS AND BARRIERS TO GENERATIVE AI ADOPTION AMONG STUDENTS OF INITIAL TEACHER EDUCATION PROGRAMMES

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Abstract

Motivation for the paper: This paper examines one of the most prolific transformations in the education context in modern times from the student perspective – that of the rapid evolution and pedagogical impact of Generative Artificial Intelligence (GenAI). This technology can be viewed both as a source of inspiration and contention. The realisation of GenAI's transformative benefits in terms of teaching, learning, and assessment needs to be appropriately scaffolded so as to ensure that students adopt GenAI in an ethically responsible manner cognizant of the importance of maintaining academic integrity. However, in most studies to date, the student voice in relation to GenAI adoption is largely unheard. *Objectives:* This paper examines the drivers and barriers to the behavioral intention to adopt GenAI among students of initial teacher education programmes in Ireland. This particular context is an interesting one as students play a dual role – as students themselves within their academic programmes and as student teachers within an external school environment. *What was done? How it was done and validated?:* A quantitative online survey instrument was developed to examine GenAI adoption drivers and barriers, with survey constructs informed by a systematic review of literature focused on AI adoption in higher education. This instrument was pilot tested, refined, and subsequently administered to a purposive stratified sample of 600 students enrolled in initial teacher education programmes in Ireland. Data collection resulted in 290 usable responses, achieving a 48% response rate. Analysis of the survey data was performed using both SPSS and N-Vivo. *Results and conclusions:* The study's findings offer illuminating insights into GenAI adoption drivers and barriers among students of initial teacher education in Ireland. The insights gleaned inform a number of recommendations regarding the need to extend existing technology adoption models to better account for the nuances of GenAI adoption and regarding the structures and supports that need to be embedded within educational institutions to foster more effective student engagement with GenAI.

Keywords: *Generative AI, GenAI adoption, drivers, barriers, higher education.*

1. Introduction

The rapid evolution and pedagogical impact of GenAI (e.g. AI chatbots such as ChatGPT) represents one of the most prolific educational revolutions in modern times. The technology's potential to positively transform teaching and learning while simultaneously threaten the foundations of higher education 'as we know it' make it both a source of inspiration and contention in the broad education context. Adoption of any new technology involves a fine balance between confidently leveraging the technology's functionalities to deliver practical benefits and between weighing the negative impacts of the technology. A review of GenAI research in higher education highlights that the student voice in terms of GenAI adoption is largely unheard in previous studies. An understanding of what motivates and deters students from adopting GenAI in their studies is a gap in the existing literature that this paper seeks to address. This paper explores the drivers and barriers of GenAI as seen through the eyes of student teachers – students enrolled in undergraduate initial teacher education programmes in Ireland. This is an interesting context to study given that such students not only need to consider the adoption of GenAI within their own academic studies but also in terms of them acting as student teachers within an external school environment. The research question addressed is as follows: *What are the drivers and barriers to GenAI adoption among students enrolled in initial teacher education programmes in Ireland?*

2. Literature review – The student perspective

The proliferation of GenAI has brought about opportunities to transform teaching and learning but in so doing poses a considerable threat to academic integrity and current approaches to learning (Mao et al, 2023). From a beneficial perspective, AI personalises the learning experience to individual learning styles, offering students adaptive and interactive learning opportunities (Bennett & Abusalem, 2024). This is particularly advantageous to students with learning difficulties, diverse learning needs, or non-native speakers (Kooli, 2023). Acting as a personal tutor, AI chatbots provide students with tailored, personalised instruction and real-time feedback enabling them to learn independently and improving their understanding of complex material (Mogavi et al, 2024). Other beneficial impacts pertain to their use within the classroom setting, supporting collaborative problem solving, student creativity, teamwork skills, and enhanced student engagement (Mao et al, 2023). From a disadvantageous perspective, GenAI poses considerable risks in terms of diminishing student critical thinking skills, writing skills, and in-depth understanding through over reliance on AI; the true learning process may be bypassed limiting student engagement with the subject matter. Further, misinformation and biases encoded in the AI system may negatively impact on a student's worldview (Kooli, 2023). The most significant challenge is the potential for academic misconduct in light of the sophistication of AI-generated content, with many students now cognisant of the implications of plagiarism for their academic grades (Wang et al, 2024). Some students using AI to produce assessment output may receive an unfair advantage over those not adopting the technology, further compromising the integrity of academic assessments (Chan, 2023).

3. Methodology

This study adopted a quantitative research approach based on the administration of an online survey instrument, whose constructs were informed by a systematic review of the existing literature. The survey sought to gather responses to a series of closed five-point likert scale questions and a number of open-ended questions to provide a richer understanding of the issue investigated. Purposive stratified sampling was employed, requiring respondents to be enrolled in undergraduate initial teacher education programmes in Ireland. The study's sample consisted of 600 students. Data collection resulted in 290 usable responses (48% response rate). Analysis of the quantitative closed questions was performed using SPSS, while the qualitative open-ended questions were coded and thematically arranged using N-Vivo.

4. Findings and discussion

4.1. Drivers

4.1.1. Enhanced student understanding. 50% of respondents (n=245) found AI chatbots increased their academic understanding. Respondents noted that AI chatbots '*break things down into manageable explanations*' and '*simplify abstract concepts'*. For some students the benefit pertained to better understanding of course material and assignments. One student mentioned the need to use AI chatbots if they were '*at a complete loss with an essay title or assignment task*'. Enhanced understanding was a result of the functioning of AI as a dialogic partner. Students mentioned the availability of and '*interactivity with an immediate tutor*' that provided '*layman explanations*' and '*broke down broad academic questions for easier digestion*'. These findings are also evident in previous studies. Mogavi et al (2024) discuss the role of chatbots in enabling students to grasp and retain complex concepts by providing students with tailored instruction, explanations, and analogies, personalised to individual learning styles. The dialogic nature of AI chatbots makes student learning more interactive and dynamic and fosters deeper understanding of the material investigated (Bennett & Abusalem, 2024). Hsiao et al (2023) further highlight the beneficial impacts of real-time feedback and independent study at students' own pace in enhancing student learning.

4.1.2. Ease of GenAI use. 67% of respondents (n=194) found AI chatbots easy to use; 52% (n=151) found interaction with them to be clear and understandable; while 55% (n=X) found that learning to use AI chatbots took little effort. The consensus among the majority was that using AI chatbots was a straightforward process, described by a number of students as '*self-explanatory*' and '*almost foolproof*'. Much previous research echoes these findings. Effort expectancy has been found to have a significant impact on the attitude and behavioural intention of higher education stakeholders towards the adoption of GenAI (Chatterjee & Bhattacharjee, 2020). Students' use of AI chatbots is related to the ease with which they provide students with answers they require in a minimum amount of time (Acosta-Enriques et al, 2024; Amer et al, 2024). Adoption is enhanced by tools that have user friendly interfaces that lowers the cognitive load particularly for those who may be less tech savvy (Gupta, 2024).

4.1.3. Enhanced student productivity. 50% of respondents (n=245) noted that they found AI chatbots useful in their academic studies, enhancing productivity in two key areas: idea generation and academic writing. AI chatbots supported the creativity and brainstorming processes enabling respondents to '*see out of the box ideas on topics*'. Students were motivated to use AI chatbots when they '*hit a block and can't get the flow of thinking going'*. Productivity was also enhanced through academic writing supports including improving sentence structure, grammar, and referencing. Similarly, a research study by Sobaih et al (2024) found that performance expectancy was the second best predictor of students' intention to use ChatGPT, with the technology enhancing student productivity. Further, Al-kfairy (2024) found that students were motivated to adopt ChatGPT because the technology could enhance their effectiveness in academic tasks. Within the classroom, AI tools can be employed to support collaborative problem solving, teamwork skills, and greater student interactivity. By pinpointing areas where students struggle, GenAI can supply on-demand resources, offering a customised learning experience (Mao et al, 2023).

4.1.4. Enhanced student efficiency. 57% of respondents (n=165) intimated that their academic queries could be answered quickly using AI chatbots. Respondents mention how GenAI '*allows you to gather a range of resources much quicker, there's no time wasting looking for references*'. Motivation to use AI was largely driven by feelings of stress which were often manifestations of a perceived '*unmanageable workload*'. Use of AI chatbots were noted to potentially give students '*extra time to focus on tasks they find hard*'. The primary benefit appeared to centre on assignment writing and avoiding '*late submissions*': it '*makes writing assignments faster when I'm running out of time*'. In previous research, efficiency in task completion, saving individuals both time and effort, is widely noted as a driver of GenAI adoption. Gupta (2024) found that the utilitarian benefits of GenAI tools enable individuals to improve their efficiency by completing research-related tasks faster, while Al-kfairy (2024) highlighted how ChatGPT streamlines more administrative-type tasks providing an enriched educational experience.

4.1.5. Resources and knowledge to support adoption readiness. 72% (n=353) and 58% (n=284) of respondents felt they had both the necessary resources and knowledge respectively to use AI chatbots. However, the GenAI competences students possessed seemed to be due to the technology's ease of use rather than specific supports provided by their university. Only 9% of respondents (n=44) felt that their university sponsored AI chatbot-related learning opportunities. One student commented: '*teach me how to use it and when in order to allow me to focus on my studies and get answers to questions when needed*'. Previous research solidifies the importance of having the necessary facilitating conditions in place (Acosta-Enriquez et al, 2024). According to Chatterjee & Bhattacharjee (2000), the availability of high quality technical infrastructure, training and other resources may help individuals to more readily adopt GenAI. GenAI literacy training and guidance on how to apply GenAI ethically and responsibly is critical in reducing the likelihood of accidental plagiarism and in reassuring those who are anxious of adopting GenAI due to misconduct concerns (Van Slyke et al, 2023).

4.2. Barriers

4.2.1. Risk of academic misconduct. 85% of respondents (n=247) suggested that use of AI chatbots increased potential for academic misconduct. Interestingly, one respondent stated: '*my only experience of students using AI is using it to cheat or plagiarise work'*. The majority of comments pertain to consequences of academic misconduct and the severity of disciplinary action. The primary concerns include the risk of '*getting poor grades*', '*failing a module or assignment'*; and '*having to repeat*'. One student commented that '*the chances of getting in trouble outweigh the reward of using it*'. Academic misconduct is a prominent issue outlined in previous studies (Mao et al, 2023), highlighting concerns of plagiarism, contract cheating, and the authenticity of student work (Moorhouse et al, 2023). Studies by Oc et al (2024) and Budhathoki et al (2024) suggest that academic dishonesty and authorship were pivotal concerns in students' decisions to adopt GenAI. Similarly, in a study of pre-service teachers, Wang et al (2024) noted how they reduced their intention to adopt GenAI due to the potential implications of plagiarism.

4.2.2. Negative impact on the overall learning experience. Only 26% of respondents (n=75) believed that AI chatbots increased their chances of getting higher academic grades. Some of the most prolific barriers to adoption pertained to the impact on students' critical thinking skills. Repondents stated '*students lose the ability to research and think for themselves if they take AI's answer as absolute fact*'. The impact of this is associated by respondents with '*lack of creativity*', whereby students '*are not able to brainstorm ideas*' or '*come up with answers/solutions on their own*'. Further, students' content knowledge and academic writing skills may be dramatically impeded. A predominant belief was that the broad sweeping capabilities of GenAI breed an air of reliance, laziness, and disengagement and negatively impact

the overall learning experience – GenAI '*reduces feelings of self-worth within students' work and gives them a false sense of achievement*'. In previous research, Chan (2023) suggested that the negative impact on students' ability to independently analyse academic challenges may be a concern for their overall skill development and, while Oc et al (2024) regard AI as useful for routine tasks, its potential to stifle intellectual development was found to be a concern. Student problem-solving skills, critical thinking skills, writing skills, and creativity were also found to be negatively impacted in previous research (Chan, 2023).

4.2.3. Potential for misinformation and bias. 79% of respondents (n=230) believed that AI chatbot generated responses were not always correct. Respondents cite '*false/fake information*' and '*misleading information*' to reflect potential outcomes from GenAI use. The possibility of relying on information that hasn't been verified is recognised as a further risk. Concerns regarding misinformation and bias and the potential for students to accept GenAI output as being the objective truth are also widely reported in previous studies. The 'AI hallucination effect' is linked to potentially poorer educational outcomes and compromised academic integrity (Mao et al, 2023). Potential exists for various types of biases to be assimilated by AI (Kooli, 2023) with negative consequences for students' real world perception. Further, Oc et al (2024) highlight that lack of transparency surrounding AI algorithms can increase student mistrust; the relative inability to trace GenAI outputs back to their original source results in a '*black box*' perception that increases reluctance towards GenAI adoption (Castelvecchi, 2016).

4.2.4. Lecturer perception of GenAI use. Only 16% of respondents (n=46) believed the university's academic staff were helpful in students' adoption of AI chatbots. The message largely reported by students was that, in the main, lecturers discouraged the use of AI chatbots within their modules. Respondents stated: '*lecturers deem AI totally wrong in an academic setting*' and '*lecturers discourage it through AI detectors and fearmongering*'. Previous studies have also raised the importance of lecturer influence. For example, Bower et al (2024) reported that the extent to which GenAI is successfully integrated in education is shaped by the openness of educators to incorporate the technology into their teaching and assessment practices. Other studies have noted that when instructors adopt supportive, knowledgeable, and transparent approaches, they tend to encourage responsible use. In contrast, unclear or punitive stances can discourage ethical engagement and heighten student anxiety towards GenAI (Mogavi et al, 2024).

4.2.5. Technological (AI) anxiety. 54% of respondents (n=156) reported that they were apprehensive about adopting GenAI. The primary anxiety pertained to the risk of plagiarism and the negative impact on the integrity of education. One student stated '*I feel apprehensive to use it due to the stigma surrounding AI chatbots*'. A further key anxiety pertained to GenAI's negative impact on critical thinking skills and the overall learning experience. Respondents noted '*I feel it is dumbing people down. The idea of a degree is to learn and use your own mind, not AI*'. For some respondents, anxiety was based on their lecturer's perception of GenAI use and their own depth of GenAI knowledge. In previous research, Wu & Li's (2025) study highlighted that the greater a person's level of AI anxiety is, the lower their level of GenAI adoption. Within the education context, studies have found that pre-service teachers' intention to use GenAI was widely impacted by AI anxiety (Falebita, 2024). Further, anxiety was a significant negative factor in students' learning motivation (Wang et al, 2024) and on their perception of success when learning in synchronous hybrid learning environments (Butz et al, 2016).

5. Conclusions

This paper has presented a detailed exploration of the drivers and barriers perceived by student teachers in terms of GenAI adoption. Of particular interest was the level of awareness respondents demonstrated of the negative implications of GenAI use. With GenAI impacting every industry and sector, graduates must be prepared for a workplace that is increasingly shaped by AI. From a practical recommendation perspective, in line with their responsibilities under the EU AI Act, higher education institutions need to foster a culture of ethical and responsible GenAI use. This involves providing AI literacy training that enables students to understand how to scrutinise GenAI outputs to recognise misinformation and biases. It also requires the rollout of AI-specific academic integrity training to make students aware of the implications of integrating GenAI into academic work, thereby alleviating concerns regarding accidental academic misconduct. Lecturers on academic programmes have an importance role to play. Those who consistently take a negative stance on AI may result in some students using AI without adequate academically-informed knowledge of AI's pros and cons; on the other hand some students who are unsure about using the technology, perhaps for reasons of technological anxiety, may be discouraged, placing them at an increased disadvantage relative to those who embrace it. From a theoretical perspective, existing technology adoption models need to be extended to account for the nuances of GenAI adoption. For

example, while most of the drivers and barriers can be explained by UTAUT (Venkatesh et al, 2003), it should be expanded to incorporate constructs pertaining to technology adoption risk and anxiety.

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#TRUSTINTRUTH: MEDIA COMPETENCE OF INVISIBLE YOUTH

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Abstract

Social media platforms such as TikTok, Instagram, and YouTube dominate information acquisition for young adults and adolescents, serving as both world-view generators (Rath, 2000) and socialization agents. More than 1 billion hours of YouTube content are consumed daily worldwide, and social media use has become a pervasive feature of everyday life for billions of users (UNESCO, 2021; Lysenstoen et al., 2021). This "always-on" culture intertwines media use with political socialization and amplifies the risks posed by disinformation, fake news, and extremist narratives, including right-wing populism (Bruns, Gläsel & Strobel, 2017; Krange et al., 2021; Tsagkroni, 2022; Berninger & Reichelt, 2022). At the same time, the ability to critically assess media content, navigate contradictory information, and identify misleading or manipulative narratives has become a key democratic competence. The research project #TrustinTruth, funded by the Federal Agency for Civic Education (*Bundeszentrale für politische Bildung*, bpb) addresses this challenge by focusing explicitly on youth whose perspectives often remain underrepresented in large-scale studies on media use and political orientation. Major studies such as JIM (Feierabend et al., 2024) or the Shell Youth Study (Albert et al., 2024) provide important general insights, yet they largely overlook marginalized youth from socio-economically disadvantaged backgrounds or with special educational needs. This creates a significant research gap regarding their media competence, understood here as the ability to "read" media, process conflicting information, detect fake news, and develop political judgment in relation to peers, parents, teachers, and digital media environments. The paper presents findings from an exploratory pilot study that formed the preparatory empirical phase of #TrustinTruth. This pilot was designed as a first systematic test run for the main project in order to gain an initial orientation regarding relevant themes, patterns of media-related judgment, and possible competence profiles among 11- to 15-year-olds at what has been described as a media-biographical turning point (Feierabend et al., 2024). Using the innovative "Picturizing Strategy"—a visual, low-threshold interview method grounded in Bronfenbrenner's ecosystemic model and concept mapping (Tkotzyk et al., 2024)—we conducted 20 baseline interviews (n=20) in inclusive educational settings. Although the pilot primarily served to prepare the main study, it already generated substantial findings that reveal noteworthy patterns in how these often "invisible" youth groups orient themselves within complex media environments. By making visible the perspectives of adolescents who are frequently overlooked in large-scale media studies, the study contributes to current debates on inclusive media education and political learning and offers impulses for educational practice in line with the UN Conventions on the Rights of the Child and of Persons with Disabilities (UNESCO, 2021; Goll, 2022; Oberle, 2017).

Keywords: *Media competence, marginalized youth, fake news, media education, political judgment.*

1. Introduction

Democracy currently faces significant challenges, including populism, hate speech, polarization, and a declining trust in political institutions (Fischer & Reinhardt, 2020). In recent years, we have witnessed the rise of various ideologies across Europe that influence people constantly.

Digital media, particularly social media, serves as a primary platform for extremist ideologies while simultaneously acting as an agent of information transmission and a worldview generator (Rath, 2000). As media functions as a central socialization agent, the ability to critically reflect and evaluate information, navigate contradictions, and identify manipulative narratives has become a fundamental democratic competence (Tkotzyk & Lategahn, 2025).

Despite their importance, major studies like JIM (Feierabend et al., 2024) or the Shell Youth Study (Albert et al., 2024) largely overlook marginalized young people from disadvantaged socio-economic backgrounds or with special educational needs. This creates a big research gap regarding their specific

media competence, which here means the ability to "read" media, process conflicting information, spot fake news, and develop political judgment in relation to peers, parents, teachers, and digital media environments. The research project #TrustinTruth, funded by the Federal Agency for Civic Education (*Bundeszentrale für politische Bildung*, bpb) addresses this problem by focusing explicitly on these "invisible" young adults.

The project pursues three main objectives. (1) Investigating media's role in political opinion formation and the recognition of disinformation through qualitative interviews. (2) Developing a Social Media Literacy Kit (SMLK) for school settings based on these findings. (3) Strengthening teachers' media literacy.

This paper presents initial findings from a preliminary study (October 2025 - January 2026) involving 20 young adults. Using an adapted "Picturizing Strategy" (Tkotzyk, Lategahn, Marci-Boehncke, 2024), the study reveals noteworthy results in how the target group navigates complex digital environments.

2. Youth, media use and political orientation

Digital media have permeated everyday life of children, adolescents, and adults (Sponholz & Boenisch, 2021), shaping social structures, perceptions, and cognitive processes (Zorn, Schluchter & Bosse, 2019). This development is part of a broader transformation from linear to non-linear, platform-based, and increasingly individualized media use. According to UNESCO (2021), more than one billion hours of video content are watched on YouTube every day worldwide, illustrating the immense relevance of digital platforms as contemporary media environments.

In Germany the JIM Study 2024 confirms this Shift toward platform-base communication: WhatsApp (96%), Instagram (62%), TikTok (54%), and Snapchat (52%) dominate the media environments of 12- to 19-year-olds (Feierabend et al., 2024).

This shift impacts political socialization, as content is increasingly consumed through algorithmically curated feeds, memes, and influencer communication. In these hybrid contexts entertainment and political persuasion overlap, making it difficult for adolescents to identify extremist political or manipulative content.

2.1. Media competence vs. media literacy

To address these challenges, it is vital to distinguish between tow relevant concepts: (1) Media competence that refers to the individual's cognitive and technical abilities to use, understand, and critique media (Baacke, 1996). (2) Media literacy that is often used in international contexts. This broader concept emphasizes the sociocultural practice and the democratic agency required to navigate media environments autonomously. In digital environments, these terms encompass the ability to evaluate sources, distinguish opinion from fact, and reflect algorithmic personalization as a fundamental democratic requirement.

2.2. The digital divide and marginalized youth

However, access to and critical use of digital media are systematically stratified by intersecting social inequalities – including gender, ethnicity, disability, and socio-economic status. These dimensions compound to produce unequal distribution of material, social, and cultural capital (Robinson et al., 2020). This multidimensional and intersectionally structured inequality in the digital realm is commonly conceptualized as the "digital divide" (Hargittai, 2002).

Adolescents with special educational needs or from precarious backgrounds are active participants in digital culture; yet their media practices, interpretive strategies, and vulnerabilities remain insufficiently visible in large-scale research. Understanding how these "invisible" groups assess credibility and recognize filter bubbles is essential for developing responsible, inclusive media education.

3. Marginalized youth as an underrepresented group in media studies

With over 600,000 students receiving special educational support in Germany (Statista, 2024). this group is a significant educational reality, yet remains underrepresented in media literacy and civic education research. This invisibility contradicts the UN Convention on the Rights of Persons with Disabilities (CRPD), which mandates full social and political participation. Nevertheless, the political agency of people with disabilities has historically often been underestimated, while their perspectives, communicative needs, and barriers to participation have not always been sufficiently considered in political institutions and civic education contexts (BMAS, 2016; Stegkemper, 2022).

Digital participation is further stratified by socio-economic background. Disadvantaged adolescents often have less access to technical devices and fewer opportunities to develop media-related competencies in supportive educational contexts (Booth et al., 2020). Their media practices may lean toward stereotypical entertainment formats (Wagner, 2010), which can limit opportunities for encountering diverse, reflective, and politically informative content.

This resource gap increases vulnerability to fake news, propaganda, and radicalizing narratives. Without adequate educational support and dialogic reflection, distinguishing between fact and manipulative framing becomes significantly more difficult (Krange et al., 2021; Berninger & Reichelt, 2022, Tsagkroni, 2022).

At the same time, adolescents with special educational needs and adolescents from disadvantaged backgrounds should not be framed as passive, deficient, or homogeneous media users. The central problem lies in the unequal distribution of resources, opportunities, and institutional support. To foster inclusive democratic education, we must understand how these "invisible" groups navigate digital media environments, encounter and evaluate political content, and how they make sense of phenomena such as fake news, filter bubbles, and manipulative narratives. This is precisely where the #TrustinTruth project intervenes.

4. Methodological approach: The picturizing strategy

To address the research gap and capture the perspectives of "invisible youth," this study employs the "Picturizing Strategy" (PS). Originally a tool for exploring political consciousness in early childhood (Tkotzyk, Lategahn, & Marci-Boehncke, 2024), the PS is a visual, low-threshold interview method. It enables participants to express experiences and judgments through images, reducing abstract verbal reasoning barriers.

4.1. Theoretical foundation and adaption

The PS is grounded in Bronfenbrenner's ecosystemic model (1979) but conceptualizes mediality as a dimension that permeates all systemic levels rather than a separate factor. While previous applications of the PS focused on a basic understanding of social rules, this study adapts the focus for 11- to 15-year-olds toward media-related judgment, information practices, and awareness of manipulative narratives.

4.2. Practical application and material

The PS functions as a communication-supported mapping activity:

- Material: Participants select from image cards representing digital media platforms, influencers, fake news, cyberbullying, or algorithmic personalization. These cards were co-creatively developed in student-led participation process, ensuring they reflect current digital lifeworlds.
- Process: Participants place cards on a "game board" while "thinking aloud". This mapping explores the micro-level (family, peers), meso-level (school, teacher), and broader societal influences.
- Benefits: The playful, action-oriented format reduces the researcher-participant-asymmetry and cognitive-linguistic barriers, making it ideal for youth with special educational needs.

The adapted PS provides access to both verbal reflections and visual mappings, allowing the recurring patterns in media use, information practices, awareness of fake news and filter bubbles, and the role of family, peers, teachers, and digital platforms in processes of orientation. The following findings are based on the preliminary study (n=20).

5. Frist insights from the preliminary study

The pilot study (n=20) reveals a contradictory picture: intensive media use coexists with limited critical reflection, highlighting the "digital divide" in practice. The findings can be grouped into three central patterns:

5.1. Hybrid media use: Entertainment vs. information

As hypothesized, social media dominates the participants' everyday lives, primarily for entertainment. One participant described media mainly as a way of "playing games and watching movies" (mC14), while another referred to TikTok as something used simply "to waste time" (mT14). However, platforms such as TikTok have simultaneously become an important source to "see what is going on" and to follow "news" content (mE15). This finding confirms that political information is now predominantly

encountered through incidental, algorithmically curated feeds, short videos, and influencer-based communication rather than traditional formats

5.2. Limited reflection and "algorithmic truth"

A significant lack of critical reflection and political judgment was evident. Political claims were often reproduced uncritically, such as a distorted political statement regarding Friedrich Merz about changing weekends and Fridays (mE15). Credibility was rarely assessed on the basis of factual or journalistic criteria; instead, trust was linked to visibility and emotional impact. One participant explained that media content seemed trustworthy because it constantly "shows what is happening" and "talks about it everywhere" (mE15). In this sense, algorithmic presence was implicitly equated with truthfulness. Although the term "fake news" was known, concrete detection strategies remained vague, for example when one adolescent stated that people should "not listen to too much of it because of fake news" (mE15). Furthermore, news was often evaluated emotionally rather than analytically, e.g. when participants described news as something that "helps" or "makes you feel less afraid" (mE15).

5.3. Validation space: Peers vs. school

The social environment plays a decisive role in information processing:

- Peer groups play a central role in validating information. They serve as a space where youth negotiate "what is true and what is right" (mE15).
- Schools remain largely irrelevant for media literacy. While devices such as iPads or learning apps are used in class (mH14; wS11), the application is strictly functional. In fact, media education is not available (wA11).

The interviews also showed that adolescents perceive digital media as attractive because they are "fun" and "not so theoretical" (mP16). This statement marks a sharp divide between institutional learning and youth' digital lifeworlds.

6. Conclusion and outlook #TrustinTruth

The preliminary findings confirm that while marginalized adolescents are deeply integrated into digital media cultures, their media competence remains largely functional. The lack of reflective and analytical strategies for evaluating political content and misinformation underscores a significant democratic deficit.

These results validate the #TrustinTruth approach and its focus on "invisible" youth. To bridge this gap, the development of the Social Media Literacy Kit (SMLK) must directly integrate the target group's actual media practices, specifically targeting source evaluation, and the deconstruction of manipulative narratives.

Furthermore, the perceived marginality of schools in fostering media literacy highlights a critical need for teacher professionalization. By providing empirically grounded, practice-oriented materials, #TrustinTruth contributes to a more inclusive and democratic media education, ensuring that those most vulnerable to disinformation are no longer overlooked.

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"BRAIN KNOWLEDGE FOR LEARNING" PROGRAM: DESIGN AND SHORT-TERM ASSESSMENT

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Abstract

Improvement of study habits in high school would prove beneficial for students at both present and future stages. This could be achieved through programs designed specifically for adolescents, which consider their greater impulsiveness, susceptibility to influence, and vulnerability to risky behaviors. The objective of the current work was to create and evaluate the effectiveness of the Brain Knowledge for Learning (BK4L) program, aimed at adolescents and focused on improving their study habits and decision-making through an understanding of the neural mechanisms involved. The BK4L-Program is based on neuroscience and designed as a voluntary out-of-class activity organized in four sessions (1h 30min each) plus a reinforcement session. The Wooclap platform was used for interactive activities. To assess the effectiveness of the program, a specific instrument (the BK4L-Questionnaire) was developed as a 5-point Likert scale (25 items), which was based on previously validated questionnaires for adolescents and adapted to the contents of the program. It was validated by 4 education experts. In addition, satisfaction with the program and knowledge acquisition were assessed. For implementation of the BK4L-Program, 104 students (15-17 years old) were recruited from two high schools and randomly assigned to control (46) or experimental (58) groups. Data from pre- and post-intervention measures were analyzed using descriptive and inferential statistics to examine changes over time. The BK4L-Program addressed topics related to neuroplasticity, attention and motivation, the reward system and addictions, study organization and planning, concept association and deep analysis, and brain health in adolescence. The validated BK4L-Questionnaire assessed three dimensions: (1) perception of study habits, including attention, motivation, and planning and deep learning; (2) perception of decision making, impulsivity, and emotional regulation; and (3) perception of brain-healthy habits. After the first stage of the program (4 sessions), the experimental group reported improvements across the three dimensions, particularly in attention and planning and deep learning indicators. Satisfaction with the program was high (4.4 ± 0.11 out of 5). The average knowledge acquisition score was 8.91 out of 10 (72.4% excellent and 20.7% very good). Overall, these findings suggest that, unlike previous interventions targeting isolated components, the BK4L-Program provides a well-accepted and effective integrative approach grounded in the mechanistic understanding of learning and decision-making, with its strongest short-term impact on students' perceived study habits and additional benefits for decision-making and brain-healthy habits.

Keywords: *Learning, neuroscience, adolescence, decision-making, Wooclap.*

1. Introduction

Recent studies have shown that university students exhibit study habits that could be improved (Vicente-Torres, 2025) and an improvement in these habits would be more beneficial if acquired before entering university. During adolescence, the activity of the brain's reward system stands out over executive functions, which leads to greater impulsivity, susceptibility to influence, and vulnerability to risky behaviors (Casey et al., 2008). A program designed to improve study habits in high school students should take these factors into account and address the multiple dimensions of learning, including those previously examined in university students: attention, motivation, planning and deep learning, and brain health (Vicente-Torres, 2025).

2. Objective

The objective of the current work was to design the Brain Knowledge for Learning (BK4L) neuroscience-informed program and its assessment instruments and to evaluate its effectiveness. This program aimed to bring scientific neurobiological mechanisms closer to adolescent students to raise awareness of the processes taking place in their brains during learning and decision-making, and to provide them with new tools to develop brain-healthy behaviors and to prevent risky behaviors such as the use of psychoactive substances or engaging in compulsive conduct.

3. Methodology

The BK4L-Program comprised four 90-minute sessions delivered over two consecutive weeks, with two sessions per week, followed by a reinforcement session approximately four months later. It was designed to be delivered in person outside regular class hours, in small groups of up to 20 students. The program used an interactive workshop format supported by the educational platform Wooclap and active learning methodologies, including question-based teaching adapted to adolescents' experiences.

To assess the short-term effectiveness of the program, three instruments were developed. First, students' perceptions of the topics addressed in the program were assessed using the BK4L-Questionnaire, a 25-item instrument based on a 5-point Likert scale and validated by four experts in education. Second, satisfaction with the program was evaluated using a separate questionnaire consisting of six items rated on a 5-point Likert scale and two open-ended questions. Third, knowledge acquisition was assessed by means of an objective test comprising 10 multiple-choice questions.

The program was implemented in two educational centers in the Community of Madrid, Spain: Francisco Ayala High School and SEI Concepción Charter School. The research protocol was reviewed and approved by the Ethics Committee of Universidad Complutense de Madrid. A total of 104 second- and third-year high school students aged 15 to 17 years were recruited on a voluntary basis and randomly assigned to either the control group (n = 46) or the experimental group (n = 58).

Baseline student perceptions prior to program implementation were assessed using the BK4L-Questionnaire, and differences between the control and experimental groups were analyzed using Student's t-tests for independent samples. The effect of the BK4L-Program on students' perceptions was then evaluated by comparing BK4L-Questionnaire responses in the experimental group before and after the intervention, using Student's t-tests for paired samples.

4. Results and discussion

4.1. Design of the BK4L-Program topics and assessment tools

The BK4L-Program was designed to provide adolescent students with an integrative view of the mechanisms underlying learning and decision-making, based on dimensions previously described (Vicente-Torres et al., 2025). Therefore, it covered the following topics: 1) Neuroplasticity, 2) Attention. motivation, reward system, and addictions, 3) Organization and planning, 4) Concept association and deep analysis, 5) The adolescent brain and 6) Brain health (nutrition, exercise, stress, sleep, emotions).

The BK4L-Questionnaire was designed to assess students' perceptions about the previous topics. Thus, its 25 items were classified in three dimensions: (1) study habits (11 items), with three subdimensions -attention, motivation, and planning and deep learning-; (2) decision-making, impulsivity, and emotional regulation (DMIER) (9 items); and (3) brain-healthy habits (5 items) (Table 1). These items were based on and adapted from various previously validated questionnaires for adolescents (Tuinstra et al., 2000; Storfer-Isser et al., 2013; Melendez et al., 2017; Soemantri et al., 2018; Cesari et al., 2024 and Davoudpour et al., 2025), and sensitive questions were avoided.

*Table 1. Validated BK4L-Questionnaire. Items, dimensions, and subdimensions are presented. All items were assessed using a 5-point Likert scale ranging from 1 (complete disagreement) to 5 (strong agreement). * Reverse-scored items.*

Dimension	Subdimension	Item
Study habits	Attention	1. I pay attention to what I am doing without getting easily distracted.
		2. I can easily concentrate on a single task when I study.
	Motivation	3. I study because I enjoy learning new things.
		4. I study mainly to get good grades rather than to learn.*
		5. I believe that what I learn at my high school will be useful for my future.
	Planning and deep learning	6. I try to keep up with class assignments.
		7. I relate what I learn in one subject to what I already know from others.
		8. Instead of memorizing, I try to understand how ideas connect to each other.
		9. I use outlines, concept maps, or summaries to organize the main ideas.
		10. Making outlines and explaining the material to a friend helps me learn.
		11. I like to think about how to explain to other people what I learn in class.
Decision-making, impulsivity, and emotional regulation (DMIER)		12. I find it difficult to finish what I start.*
		13. Sometimes I act without thinking about the consequences.*
		14. Sometimes, when I am with my friends, I find it hard to control my impulses.*
		15. Even if others have different opinions, I stick to my decisions without feeling bad.
		16. When I work in a group, I am able to contribute ideas and reach agreements without losing control.
		17. I make decisions thinking about how they may affect my study and life goals.
		18. I get overwhelmed easily.*
		19. I have sudden outbursts of anger.*
		20. When something goes wrong for me, I manage to calm down in a short time.
Brain-healthy habits		21. I get enough sleep and feel rested in the morning.
		22. I do physical activity for one hour or more a day (sports, brisk walking, dancing, etc.).
		23. I eat a healthy breakfast before going to high school.
		24. I eat fruits and vegetables several times a day.
		25. I usually consume fast food or pastries several times a week.*

4.2. Assessment of the BK4L-Program short-term effectiveness

The initial perceptions (prior to receiving the BK4L-Program) of the students regarding their study habits, decision-making, and brain-healthy habits were similar between control and experimental groups, given that no statistical difference was detected in any of the five indicators analyzed (attention, motivation, planning and deep learning, DMIER and brain-healthy habits) (Figure 1A). Mean scores for each indicator were at mid-range levels within the five-point scale used; the lowest perception values observed were for attention and motivation, which may represent an opportunity for improvement in aspects related to student engagement.

After the first stage of the program (4 sessions), the experimental group reported moderate but statistically significant improvements across all the dimensions analyzed, particularly in attention (25.01 ± 6.04 %), planning and deep learning (17.17 ± 3.08%), and motivation (11.06 ± 3.34%), although motivation was the only indicator that remained below the mid-range level (Figure 1A, B). These indicators are directly related to key cognitive processes involved in learning, suggesting that the intervention had a particularly positive impact on students' perception of their study habits. Additionally, it also positively influenced variables related to decision-making and brain-healthy habits.

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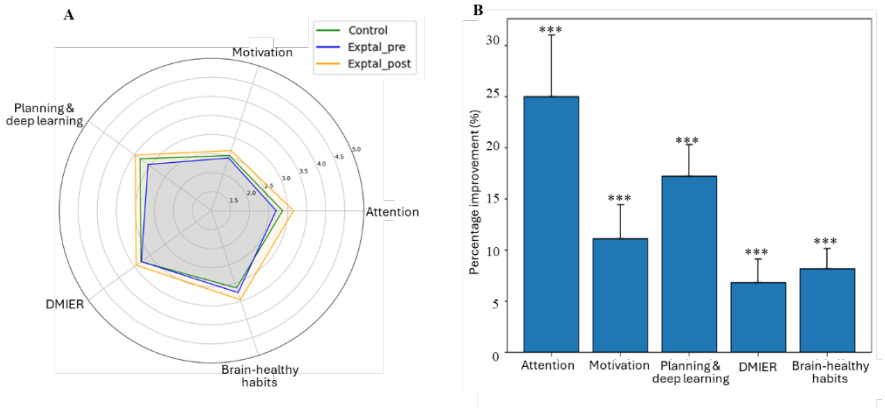
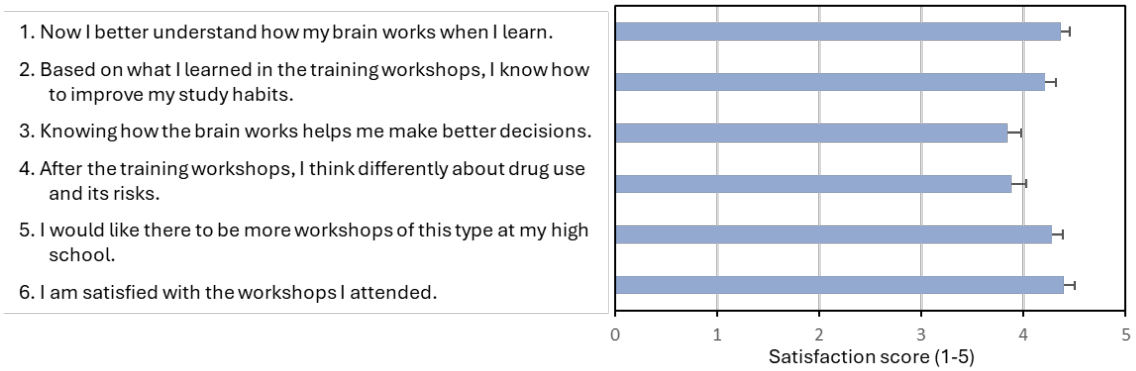
*Figure 1. Impact of the BK4L-Program on students' perceptions of their study habits, DMIER and brain-healthy habits. (A) Radar plot showing the three conditions: control, experimental pre-program, and experimental post-program. (B) Bar graph showing percentage improvement after the intervention in the experimental group (mean ± SEM). The short-term impact of the BK4L-Program, assessed by comparing pre- and post-program values, was significant across all dimensions analyzed (***P < 0.001, Student's t-test).*



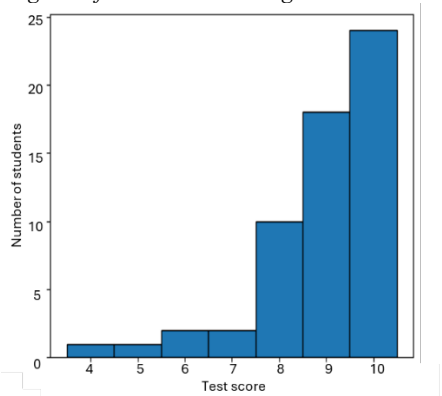
Overall satisfaction with the program was high (4.4 ± 0.11 out of 5; item 6 of the satisfaction questionnaire) (Figure 2). All aspects evaluated received positive ratings. Students rated highly the workshops and their contribution to understanding brain functioning, and reported that the program helped them improve their study habits and reflect on their decision-making, indicating its relevance from both academic and personal perspectives.

Figure 2. Student satisfaction scores for the six BK4L-Program items (mean ± SEM). Ratings were obtained using a 5-point Likert scale ranging from 1 (complete disagreement) to 5 (strong agreement).



Furthermore, the mean score on the objective knowledge test was 8.91 ± 0.19 out of 10, with 72.4% of students rating it as excellent and 20.7% as very good, indicating effective knowledge acquisition in most participants. Overall, the results suggest a high and relatively homogeneous level of learning, with only a few isolated cases of lower performance. Together with the high satisfaction ratings, these findings indicate that the program was both well received and effective in terms of learning outcomes.

Figure 3. Histogram of students' knowledge scores on an objective test.



5. Originality, relevance and conclusions

The BK4L-Program differs from previous neuroscience-based educational interventions, which have generally focused on specific learning-related components, such as motivation, executive functions, emotion regulation, or brain health, or have been developed from predominantly psychological perspectives (Thomas et al., 2019; De Pablo et al., 2020; Debenham et al., 2024). In contrast, the BK4L-Program provides adolescents with an integrative, mechanistic view of how the brain operates during learning, translating neuroscience knowledge into a format aimed at improving learning and decision-making. This approach is consistent with adolescents' search for self-understanding and their natural curiosity. Notably, short-term assessment revealed integrated positive effects across the three dimensions analyzed, most notably in the perception of study habits, but also in decision-making and brain-healthy habits. Together with the high satisfaction and knowledge acquisition scores, these findings suggest that the program may have benefits extending beyond students to their schools, families, and the broader community.

Acknowledgements

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AN EDUCATIONAL MODEL FOCUSED ON COMPREHENSIVE UNIVERSITY EDUCATION: EXPERIENCES IN ITS IMPLEMENTATION

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Abstract

The U50 Educational Model is an institutional framework that expresses the essence, educational style, and activities of UPAEP University. It is defined as a specific approach to planning, developing, and evaluating a particular educational proposal that seeks the holistic development of students so that they, as graduates, can impact social transformation. This educational model has three constituent dimensions: identity, pedagogy, and formative. Its formative dimension fosters the creation of meaningful learning experiences through teaching methodologies based on active learning approaches such as case studies, problem-based learning, challenge-based learning, inquiry-based learning, and simulation-based learning, among others. Through these methodologies, students critically examine key social challenges from the perspective of their disciplinary training. Simultaneously, they develop generic skills, including social commitment, creative thinking, research, reflective thinking, and collaborative work. The purpose of this research project was to evaluate the level of use of teaching methodologies and assessment tools most frequently employed by teachers. The research methodology consisted of an exploratory survey of teachers´ perceptions, followed by a basic statistical frequency analysis, and finally, a qualitative interpretation of the collected information. The findings reported in the research demonstrate a high frequency of use of the teaching methodologies suggested in the institutional educational model, with challenge-based learning, problem-based learning, and teamwork being among the most frequently used. It is worth mentioning that the teaching methodology employed by the professors is aligned with both the academic program profile and the specific subject they teach. Finally, regarding the learning assessment process, the results highlight the use of rubrics as assessment tools. With the aim of comprehensively evaluating student development, this research project considered the results of an institutional evaluation of co-curricular activities conducted in the areas of professional internships, internationalization, entrepreneurship, and leadership training. The evaluation mechanisms for these activities employ assessment matrices to identify the learning outcomes achieved by students in the development of soft skills.

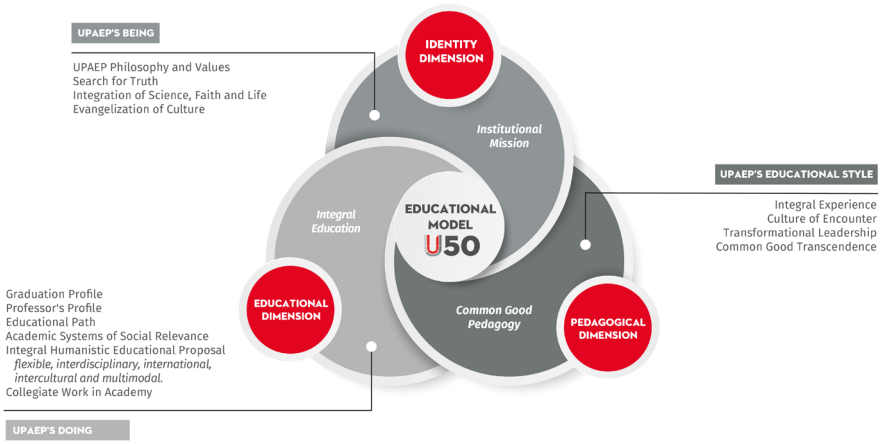
Keywords: *Comprehensive training, active methodologies, co-curricular learning outcomes.*

1. Introduction

The U50 Educational Model is an institutional proposal that expresses the essence, the style of educating, and the endeavors of UPAEP University. It is defined as a specific way in which its educational proposal is envisioned, developed, and evaluated with a clear intention: the formation of leaders with high-level professional training who, through service, positively impact social transformation and assume their roles as promoters of the common good. This educational model consists of three dimensions: the identity dimension, the pedagogical dimension, and the formative dimension. The identity dimension describes its foundational charism; UPAEP University possesses an origin and style that characterizes the training of its graduates, disposing them to serve others through the comprehensive development of their talents to promote social leadership and their impact on the transformation of temporal realities for the sake of the common good. The Pedagogy of the Common Good is the theoretical foundation of the pedagogical dimension. This pedagogy is the institutional educational style and centers on the educational relationship between the professor and the student. This relationship is close and supportive—a mutual exchange that allows both professor and student to enrich themselves as individuals by experiencing the relationship with the "other" as a personal encounter, making the construction of meaningful learning and the development of generic competencies possible. As for the third dimension, the formative dimension, it constitutes the faculty's framework of action, from which meaningful educational experiences are generated during the university formative journey. The university training phase is the heart of the student's comprehensive

development. It is characterized by pedagogical processes involving learning, teaching, and assessment strategies and activities developed by the professor to promote active learning and meaningful experiences. The formative dimension is energized by: planning, through a learning guide; development, through active teaching methodologies; and evaluation, based on a system of learning outcomes and performance evidence. The university formative journey of students within the context of the U50 Educational Model is supported by accompaniment processes that seek to impact all dimensions of the student's personhood, oriented toward their personal, academic, and professional development to favor the achievement of the institutional graduate profile (UPAEP, 2021) (Figure 1).

Figure 1. The U50 Educational Model.



2. Objective

To evaluate the characteristics of teaching practice in terms of the type of active methodologies, assessment instruments, and learning environments most frequently used by university professors in the context of the U50 Educational Model.

3. Methods

The research methodology consisted of an exploratory study that gathered professors' perceptions regarding the types of teaching methodologies, assessment instruments, and learning environments they use most in their classes. Data collection was carried out through a survey composed of the following questions:

- ¿When planning the subject(s) you teach and developing the corresponding learning guide, how often do you include active methodologies?
- ¿Which active methodology or methodologies have you used most frequently when teaching your subject(s)?
- ¿Which instruments or strategies do you use to evaluate your students' learning outcomes?
- ¿What are the learning environments you commonly use to facilitate your students' performance?

In the case of co-curricular activities, the methodology employed involved the application of assessment matrices with performance criteria distributed across the following levels: *below standard, approaching standard, at standard, and above standard*. Finally, the data obtained were subjected to a frequency analysis using basic statistical methods, and the results are presented through graphs and tables to facilitate understanding.

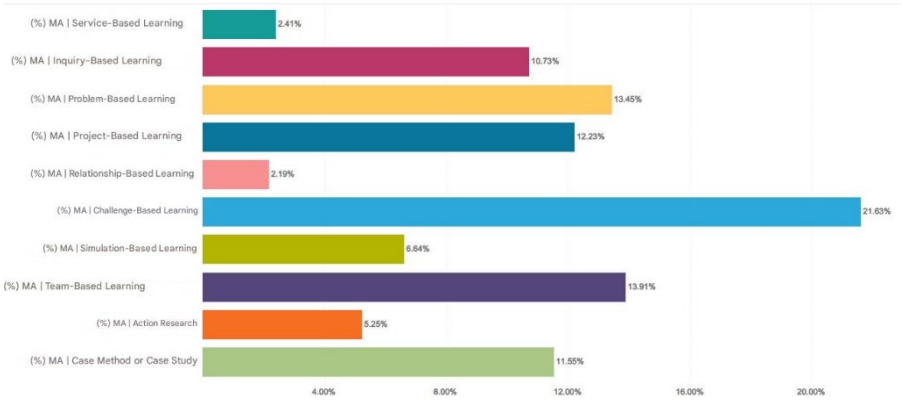
4. Discussion

4.1. Active methodologies and learning environments

The context of global education is undergoing a radical transformation regarding methods, content, and learning spaces. Today more than ever, a change in the educational paradigm is necessary, implying a restructuring of the curriculum and a revolution in faculty didactics. This revolution requires the use of new teaching and learning methodologies to ensure active students and favor the development of cognitive competencies and soft skills. Addressing this challenge in education, the U50 Educational Model, in its formative dimension, suggests the use of active teaching methodologies such as: Problem-Based Learning,

Challenge-Based Learning, Service-Learning, Case Method, Project-Based Learning, Research-Based Learning, Relationship-Based Learning, Simulation-Based Learning, Teamwork-Based Learning, and Action-Research (UPAEP, 2021). These active methodologies favor the development of both transversal and disciplinary competencies, notably problem-solving, critical thinking, analytical thinking, reflective thinking, creativity, and collaborative work (Sánchez & Morales, 2019). The teaching methodologies used most frequently by UPAEP University professors are presented below (Figure 2).

Figure 2. Active methodologies used most frequently by UPAEP professors.

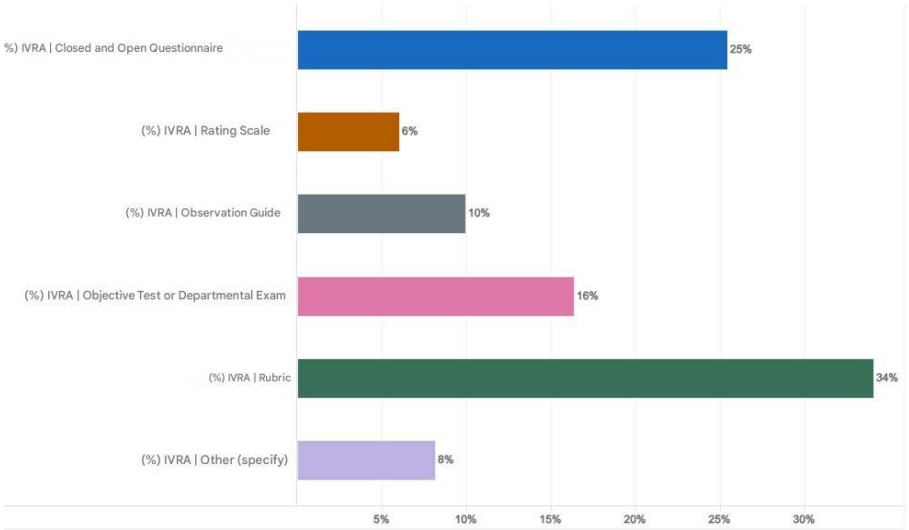


The results reported in this first phase indicate that the three main methodologies used, in order of frequency, are: Challenge-Based Learning, Teamwork-Based Learning, and Problem-Based Learning. Surveyed professors report that the classroom remains the most frequently used learning environment, followed by laboratories for practical development, and thirdly, virtual classrooms on the Canvas platform. Through the use of these methodologies, it is possible to sensitize and commit students to addressing major social challenges in an immersive way, thereby generating social intervention projects that aim to contribute solutions to specific problems. Furthermore, they develop competencies such as critical thinking, collaboration, and communication (Dikilitas et al., 2025). These findings are consistent with the pedagogical proposal of the educational institution in this study, as its institutional mission declares its goal is to form leaders who transform society.

4.2. Assessment process

Regarding the evaluation process, at UPAEP, it is carried out both in a decentralized and centralized manner. In the first case, the academic programs define the strategies, instruments, and evaluation parameters to be used to identify the level of understanding and application of the content developed by professors in their classes. The following figure represents the evaluation instruments most frequently used by university professors (Figure 3).

Figure 3. Evaluation strategies used by professors at UPAEP.



In the previous graph, percentages showing the highest use of various evaluation instruments are observed, highlighting primarily the use of rubrics and questionnaires with closed and open questions. These findings suggest that the evaluation carried out by professors in the context of the UPAEP educational model is formative in nature. It seeks not only to identify the memorization of concepts and facts but also to recognize the execution level of competencies related to the subjects in the institution's academic programs. Thus, it is a more holistic, objective, transparent evaluation aligned with the pedagogical perspective of the U50 Educational Model (Tian & Tong, 2026).

4.3. Evaluation of co-curricular training

UPAEP University promotes the comprehensive training of its students. This includes solid preparation for professional practice, the acquisition of humanistic and cultural references, the adoption of healthy lifestyles, and accompaniment to discover their vocation and sense of life. In this context, co-curricular training is understood as that which is developed through activities, programs, or learning experiences that complement what is learned in the classroom; most are extra-curricular, do not grant an academic degree, and rather reinforce the institutional graduate profile during the formative journey (UPAEP, 2024). International experiences, social entrepreneurship, and leadership training stand out as co-curricular activities. Regarding the evaluation of these activities, a centralized type of evaluation is performed, coordinated by the institutional evaluation center. Assessment matrices are designed and implemented to identify the execution level of competencies related to this type of training. For international programs, global learning is evaluated; in the case of entrepreneurship, systemic thinking and proactivity are the assessed competencies; and leadership development is valued through competencies of social commitment, healthy lifestyles, and the establishment of a life plan. The first measurement experience of these activities yielded the following results (Table 1).

Table 1. Co-curricular activities and developed competencies.

Co- curricular Activity	Competencies	Results
International Programs	Global and intercultural learning	Exchanges, research stays, and double degrees are the programs that most favor the development of intercultural competence.
Entrepreneurship	Systemic thinking and proactivity	A higher percentage of students are positioned at the "at standard" and "above standard" levels for the proactivity competence.
Lidership	Social commitment, healthy lifestyles, and life plan establishment	Social commitment was the competence with the highest development percentages, followed by life plan, and finally, healthy lifestyles were located in the lowest range of development.

5. Conclusions

The following conclusions are derived from the results and the evaluation of the implementation of the UPAEP University institutional educational model.

- Consolidation of Active Methodologies: It is confirmed that the implementation of the U50 Educational Model has successfully integrated active teaching methodologies, with Challenge-Based Learning (21.63%), teamwork (13.91%), and Problem-Based Learning (13.45%) standing out as the most frequent. These practices maintain close coherence with the institutional mission of forming leaders capable of generating intervention projects for social transformation.
- Evolution toward Formative Assessment: The evaluation process at the university has moved beyond mere memorization, orienting itself toward a formative, holistic, and transparent approach. The predominant use of rubrics (34%) as the main evaluation tool demonstrates a commitment to measuring the execution level of competencies and learning outcomes objectively and comprehensively.

- Efficacy of Co-curricular Training: Activities outside the classroom are fundamental for comprehensive training, achieving significant results in the development of soft skills. The impact of international programs on intercultural competence and the high level of social commitment achieved in leadership activities are especially noteworthy.

Finally, an area of opportunity exists in the potential to continue diversifying learning environments toward more experiential learning settings. It is concluded that the U50 Educational Model stands as a solid operational framework where institutional identity is effectively articulated with pedagogical practice and evaluation processes, fulfilling the purpose of offering comprehensive university training.

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TALKING IT OUT: USING INTERACTIVE ORAL ASSESSMENT TO AUTHENTICATE LEARNING IN AN AGE OF GEN AI

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Abstract

Generative Artificial Intelligence (GenAI) has intensified concerns regarding academic integrity and the validity of traditional higher education assessment. This paper presents two case studies examining interactive oral assessment approaches designed to strengthen assessment authenticity in AI-rich environments. The first explores a face-to-face group presentation incorporating spontaneous questioning and collaborative reasoning among undergraduate students. The second examines a fully online Individual Interactive Oral Assessment (IOA) involving adaptive one-to-one dialogue with postgraduate learners. Drawing on theories of authentic assessment, formative assessment, service quality, and learning-oriented assessment, the paper argues that dialogic assessment formats provide a sustainable alternative to surveillance-based responses to GenAI. Findings indicate that assessment designs centred on interaction, contextualised reasoning, and live explanation reduce opportunities for AI-assisted substitution while enhancing student engagement and confidence. The paper concludes that authentic oral assessment can preserve validity, integrity, and educational value in contemporary higher education.

Keywords: *Interactive oral assessment, Generative Artificial Intelligence, authentic assessment, academic integrity, higher education.*

1. Introduction

Generative Artificial Intelligence (GenAI) tools are increasingly embedded within students' academic practices, enabling rapid generation of text, arguments, and summaries. Although these technologies may support learning, they challenge assumptions surrounding authorship, originality, and the reliability of traditional written assessment. Unsupervised coursework completed asynchronously now provides limited evidence of students' independent understanding. Institutional responses have largely focused on AI-detection tools and restrictive policies. However, detection systems remain unreliable and ethically contested, while prohibition-based approaches risk limiting innovation and damaging trust. GenAI has therefore exposed a broader issue within higher education: the overreliance on product-focused assessment that privileges outputs over learning processes. This paper argues that assessment integrity should be addressed through authentic assessment design rather than surveillance. Two case studies are presented to demonstrate how dialogic and interactive assessments can preserve validity by requiring students to explain, justify, and apply understanding in real time.

1.1. Authentic assessment

Authentic assessment involves tasks that reflect real-world professional practice and require students to apply knowledge meaningfully within contextualised environments (Gulikers et al., 2004). Gulikers et al.'s five-dimensional framework (task, physical context, social context, assessment form, and criteria) provides a useful structure for evaluating authenticity in assessment design. Assessments that score highly across these dimensions are more likely to promote transferable learning and resist generic AI-generated reproduction. Within AI-rich environments, authenticity functions as a mechanism of assessment resilience. Tasks involving live communication, professional judgement, and contextual explanation reduce opportunities for AI substitution while foregrounding students' own reasoning processes.

1.2. Formative assessment and dialogue

Nicol and Macfarlane-Dick (2006) emphasise the importance of formative assessment in supporting self-regulated learning. Central principles include feedback dialogue, opportunities for

reflection, and clarity regarding assessment expectations. Interactive oral assessments align closely with these principles by allowing assessors to adapt questioning, probe understanding, and provide immediate feedback. Dialogic assessment formats also blur the distinction between formative and summative assessment, enabling assessment encounters to simultaneously support learning and evaluate performance.

1.3. Learning-oriented assessment and service quality

Race (2001) argues that effective assessment should actively contribute to learning through engagement, articulation, and feedback. Oral assessments operationalise these principles by requiring students to explain, justify, and refine understanding in real time. Additionally, Parasuraman et al.'s (1985) service quality model offers a complementary perspective by framing assessment as a relational experience. Dimensions such as reliability, responsiveness, and assurance are particularly relevant within interactive assessments, where fairness and student confidence are shaped through interpersonal engagement.

2. Methodology

This paper adopts a qualitative case study approach to examine two assessment designs implemented across contrasting higher education contexts. The cases were selected to demonstrate complementary approaches to dialogic assessment: one group-based and face-to-face, and the other individual and fully online. Data sources included assessment design documentation, reflective accounts from teaching staff, and anonymised student feedback collected through module evaluations. The analysis was intended to generate transferable insights into assessment resilience within AI-rich environments rather than statistically generalisable findings.

3. Case study one: Face-to-face group presentation

3.1. Context and design

The first case study involved final-year undergraduate students completing a face-to-face group presentation within a capstone module. Students collaboratively investigated a complex disciplinary problem before delivering a structured presentation followed by an interactive question-and-answer session. Assessors engaged students in spontaneous questioning that required clarification, elaboration, and collaborative reasoning. Although students were permitted to use GenAI tools during preparation, no scripts or pre-generated responses could be relied upon during the live assessment.

3.2. Authenticity and integrity

The assessment aligned strongly with Gulikers et al.'s (2004) framework for authentic assessment. The task mirrored professional communication practices, emphasised collaboration, and foregrounded real-time reasoning. Assessment criteria prioritised conceptual understanding, coherence, and responsiveness rather than rehearsed content reproduction. The interactive questioning phase proved particularly significant for academic integrity. Students were required to explain choices, respond to counterarguments, and negotiate meaning collaboratively, substantially reducing the feasibility of AI-generated substitution.

3.3. Educational value

Consistent with Race's (2001) learning-oriented perspective, students reported that preparing for and participating in the presentation deepened their understanding and increased confidence. The assessment was perceived as rigorous but fair, with integrity emerging from demonstrated competence rather than surveillance or compliance measures.

4. Case study two: Individual Interactive Oral Assessment (IOA)

4.1. Context and design

The second case study explored a fully online Individual Interactive Oral Assessment (IOA) conducted with postgraduate learners. Each student participated in a scheduled one-to-one oral assessment lasting approximately 25 minutes. The structure combined pre-published thematic prompts with adaptive questioning tailored to individual responses. Students were encouraged to draw on professional or disciplinary contexts, ensuring that responses remained personalised and situated.

4.2. Formative and integrity functions

The IOA operationalised Nicol and Macfarlane-Dick's (2006) formative assessment principles by enabling immediate feedback, clarification, and dialogue during the assessment encounter. Assessors could

probe understanding, request examples, and address misconceptions in real time. From an integrity perspective, personalised questioning made generic AI-generated responses ineffective. Students' ability to articulate contextualised reasoning became the primary evidence of learning, reinforcing both validity and reliability.

4.3. Student experience and service quality

Applying Parasuraman et al.'s (1985) framework, the IOA demonstrated strong alignment with reliability, responsiveness, and assurance. Standardised assessment structures supported consistency, while adaptive dialogue created a supportive and transparent environment. Student feedback indicated high levels of trust in the process and recognition of the assessment's authenticity.

5. Discussion

The case studies demonstrate that assessment resilience in the GenAI era is strengthened through interaction, contextual understanding, and live reasoning. Rather than treating AI solely as a threat, these approaches recognise its role within preparation while reserving summative judgement for independently demonstrated understanding. The findings also challenge deficit-oriented approaches to academic integrity by reframing integrity as the presence of credible evidence of learning rather than the absence of misconduct. Although concerns regarding workload and scalability remain, strategically implemented dialogic assessments may reduce time spent addressing academic misconduct cases while improving assessment authenticity and student trust.

6. Implications for Practice

Several implications emerge for educators and institutions seeking to redesign assessment within AI-rich environments:

- Prioritise assessment formats requiring interaction, explanation, and contextual judgement.
- Explicitly integrate ethical GenAI use into assessment guidance.
- Evaluate assessment quality in terms of learner experience alongside psychometric robustness.
- Invest in staff development focused on dialogic assessment literacy.

These principles support assessment approaches that remain educationally meaningful while responding constructively to technological change.

7. Conclusion

Generative Artificial Intelligence has intensified existing challenges surrounding assessment authenticity and academic integrity within higher education. However, it has also created opportunities to reconsider how learning is evidenced and evaluated. The case studies presented demonstrate that authentic, dialogic assessment designs can strengthen integrity, validity, and educational value without relying on surveillance-based approaches.

Interactive oral assessments provide a constructive and sustainable response to the pedagogical disruptions introduced by GenAI by foregrounding explanation, reasoning, and contextual understanding. Rather than representing a defensive reaction to AI, these approaches reorient assessment toward practices that better reflect how learning occurs and should be recognised in contemporary higher education.

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BEYOND TECHNICAL PROFICIENCY: CONCEPTUALISING INTERCULTURAL PROJECT-BASED LEARNING THROUGH THE GIPE AND GIPE++ INITIATIVES

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Abstract

In response to the growing limitations of traditional internationalisation in higher education, this paper proposes Intercultural Project-Based Learning (IPBL) as a transformative pedagogical framework that enables meaningful intercultural engagement beyond short-term mobility and passive cultural exposure. While international initiatives have expanded globally, many educational models still fail to provide students with sustainability-related contexts, where environmental problems are inseparable from cultural practices, community structures, and socioeconomic realities. Drawing on a longitudinal, practice-based analysis of the Global Intercultural Project Experience (GIPE) and its evolution into GIPE++ between 2020 and 2026, this study examines how blended mobility models and real client projects can foster deeper intercultural learning. Particular focus is given to the GIPE++ 2025 project on Untung Jawa Island, Indonesia, where students and experts from Germany, Indonesia, Namibia, and Peru collaborated in interdisciplinary streams to develop digital platforms, tourism development strategies, innovative promotional approaches, and baseline environmental reports for a local tourism organisation. The study highlights how intercultural communication competence, defined through tolerance, dialogue, cooperation, and international perspectives, becomes a critical condition for effective IPBL implementation. Furthermore, this paper introduces the concept of productive intercultural friction, emphasising that differences in cultural expectations, communication styles, and decision-making practices can serve as catalysts for creativity, adaptability, and transformative learning when appropriately facilitated. Ultimately, the findings suggest that intercultural competence is most effectively developed through co-creation under real-world constraints, positioning IPBL as a scalable and impactful approach to rethinking internationalisation and sustainability education in higher education.

Keywords: *Intercultural project-based learning, collaborative online international learning, intercultural communication competence, interdisciplinary collaboration, international education.*

1. Introduction

In the contemporary landscape of higher education, the imperative to equip students for globally distributed and interdisciplinary professional environments has never been more acute. However, a critical gap persists: traditional internationalisation strategies frequently prioritise physical mobility and internationally themed curricula over the cultivation of substantive intercultural competence. Such conventional approaches often fail to foster the collaborative resilience and systemic thinking required to navigate the wicked problems of the 21st century, such as climate change, social inequality, and resource scarcity. Consequently, mere global exposure does not inherently translate into the ability to address complex, transnational challenges that are deeply embedded in diverse cultural and governance structures.

To bridge this pedagogical divide, this study proposes Intercultural Project-Based Learning (IPBL) as a transformative framework. IPBL transcends disciplinary silos by integrating technical expertise with ethical awareness and stakeholder engagement within an experiential learning process. The conceptual evolution of this framework is evidenced by the Global Intercultural Project Experience (GIPE and GIPE++), an international initiative spanning universities across four continents between 2020 and 2026. What began as a technically oriented collaboration has matured into a sophisticated model for sustainability-oriented action and intercultural co-creation.

A pivotal case study within this longitudinal analysis is the 2025 GIPE edition, which focused on the sustainable revitalization of Pulau Untung Jawa, Indonesia. In collaboration with local organisations, students confronted multifaceted challenges, including mangrove degradation and waste management, while navigating disparate communication styles and academic structures across multiple time zones. Central to this experience is the concept of 'productive intercultural friction' (Dahlberg, Sitter, Woody, & Ketcher, 2025). Rather than viewing cultural and disciplinary disagreements as obstacles to be minimized, the IPBL framework recognises them as essential catalysts for innovation, empathy, and adaptability.

Ultimately, this research asserts that intercultural agility is not acquired through passive observation but is forged through the rigorous process of co-designing solutions under real-world constraints. By synthesizing longitudinal data and practical application, this paper contributes to the discourse on transformative learning, arguing for a shift toward educational models that are as interconnected and complex as the global challenges they seek to resolve

2. Related work

Project-Based Learning (PBL) effectively promotes hands-on learning through real-world challenges (Bender, 2012), fostering the critical thinking and collaboration skills required in professional settings (Krajcik & Shin, 2014). Addressing complex modern issues further necessitates collaborative, cross-disciplinary solutions. Intercultural and Interdisciplinary Project-Based Learning (IPBL) addresses these needs by combining diverse cultural settings to enhance global communication and understanding Hart (2019) highlights how structured interaction and reflective practice within IPBL significantly improve students' intercultural competence alongside academic learning. Furthermore, Oladiran et al. (2011) demonstrate via the Global Engineering Teams (GET) program how technology facilitates virtual international collaboration with industry partners, allowing students to apply their diverse knowledge and cultural perspectives to create innovative solutions.

The Empathy Project, organised by the NGO Sociopreneur Indonesia (SID), exemplifies intercultural collaboration through a volunteering-based initiative involving university students and lecturers across Indonesia. The 2024 iteration focused on "Eco-Literacy for Sustainability," where "Youth Volunteers" (students) and "Expert Volunteers" (lecturers) formed small working groups to produce educational videos for children's communities in Bandung, West Java. Within these groups, students assumed specialised roles, including Project Leader, Storyline Writer, Graphic Designer, Video Editor, and Social Media Campaigner, while Expert Volunteers provided mentorship and subject-matter expertise. This collaborative process translated conceptual material into practical content, resulting in final educational video outputs aligned with the core sustainability theme (Sociopreneur Indonesia, 2024).

The diverse origins of students and experts from various Indonesian universities introduced unique values and norms into the project's collaborative dynamics. This intercultural framework stimulated novel ideas that likely would not have emerged in homogeneous groups. While these cultural differences necessitated strong communication skills to navigate disagreements arising from varied perspectives, the program's conflict management mechanisms became a distinctive and valuable outcome of the collaboration.

Collaborative Online International Learning (COIL) is recognised as an innovative, cost-effective method to promote intercultural learning through online faculty and student collaboration across countries (Rubin, 2017). Although online collaboration in student projects began in the 1990s, the focus on international intercultural aspects has gained prominence only recently (Appiah-Kubi & Annan, 2020).

Focusing on sustainability challenges, Sulkowski, Kowalczyk, Ahrendsen, Kowalski, and Majewski (2020) highlight a program where students from various disciplines and countries collaborate on projects aimed at promoting sustainable development. The initiative showcases how PBL with an intercultural and interdisciplinary focus can lead to innovative approaches to sustainability, encouraging students to think critically about environmental, economic, and social issues from a global perspective.

3. Conceptual framework: Defining Intercultural Project-Based Learning (IPBL)

Based on the background discussed in the previous chapter regarding Project-Based Learning, particularly Intercultural Project-Based Learning (IPBL), it can be understood that the fundamental concept underlying the implementation of IPBL is Intercultural Communication Competence. First, it is important to understand the concept of culture as the primary foundation. Culture is defined as learned norms, values, knowledge, artefacts, language, and symbols that are continuously communicated among people who share a common way of life (Calhoun, 1994). In addition, culture can also be understood as an umbrella term that

provides direction for individuals regarding social behaviour and norms in society, including knowledge, beliefs, laws, customs, and habits (Taylor, 1958).

Intercultural communication generally refers to interaction between individuals from different cultural backgrounds, aimed at sharing information across cultures (Jacob, 2011). In this context, intercultural communication is closely associated with cross-cultural communication, a field that examines how individuals from different cultures communicate in both similar and different ways. The importance of intercultural communication has increased due to market globalisation, technological advancement, intercultural workforces, global teamwork, and the growing demand for adaptable talent (Dirgeyasa, 2022). Based on these factors, IPBL can be understood as an educational approach shaped by global business opportunities and technological advancements. In practice, IPBL involves intercultural workforces operating within international teamwork structures. Therefore, strong Intercultural Communication Competence is essential for individuals participating in IPBL.

Furthermore, Intercultural Communication Competence is essential to reduce communication barriers such as language differences, misunderstandings, and even stereotypes. Several specific practical criteria can be used to define Intercultural Communication Competence (Dirgeyasa, 2022):

(1) Willingness to accept differences, (2) Increased tolerance, (3) Promotion of dialogue, (4) Creation of cooperation among members, (5) Development of positive attitudes toward others, and (6) Development of international perspectives.

These criteria can be viewed as key conditions of Intercultural Communication Competence that individuals should demonstrate when participating in IPBL. In short, IPBL can only function effectively when these competencies are applied, as the method requires collaboration among individuals from diverse cultural backgrounds within global teams supported by technological advancement.

4. Methodology: A longitudinal, practice-based research approach

The GIPE Educational Model has evolved over a decade from bilateral software engineering projects into a robust framework for global, interdisciplinary student projects that address the UN Sustainable Development Goals (SDGs). Initiated in 2014 between German and Namibian universities, the model originally focused on distributed software development and short on-site visits to strengthen intercultural awareness.

In 2019, supported by the DAAD, the framework integrated International Project-Based Learning (IPBL) and Collaborative Online International Learning (COIL), augmented by physical mobility. This allowed students from Germany, Indonesia, Namibia, and Peru to gain a comprehensive Global Intercultural Project Experience (Meyer et al., 2022a). The model employs a four-phase cycle:

- Online Collaboration Preparation: Virtual kick-off and targeted training.
- Two-week Face-to-Face Phase: A "Spring School" in Germany for team-building and intercultural exposure.
- Online Collaboration: Students work in mixed teams using web-based tools, guided by international academic staff.
- One-week Project-Touchdown: A handover phase where German students travel to the client in the partner country.

While the 2020 and 2021 projects were restricted by the COVID-19 pandemic, necessitating "pure COIL" or hybrid formats, they remained successful. However, we have explicitly argued that physical meetings during the Spring School are essential for the social cohesion required by our approach (Meyer et al., 2022b). The model's scope matured from independent sub-projects (2020–2021) to integrated solutions. In 2022, serving a school in Peru, student mobilities in both directions fostered deeper intercultural understanding and the "GIPE family" identity. By 2023, collaboration with UNDP Accelerator Labs marked a shift to globally distributed clients. This allowed for the full implementation of the "Local-Presence-Online-Presence" pattern, where students gather requirements locally before convening for physical and virtual collaboration. Observations from the 2023 GIPE Conference (GIPECon) confirmed that this sequence optimises intercultural awareness and yields significant institutional impact for both students and staff (Meyer, 2024a).

To ensure long-term sustainability, GIPE has transitioned into the GIPE++ framework, funded by DAAD and Erasmus+. This iteration shifts from multi-disciplinarity (independent tasks) toward true interdisciplinarity, where students from diverse fields co-create holistic solutions to complex problems, e.g. the 2025 GIPE++ project in Indonesia addresses environmental degradation through an integrated approach involving baseline studies, business modelling for sustainable tourism, and technological platforms for waste management. This holistic framework fosters innovative problem-solving and cultivates critical soft skills, including teamwork and conflict resolution, by requiring students to navigate differing disciplinary perspectives and cultural backgrounds (Meyer, 2024b).

5. Case study: The GIPE++ 2025 Untung Jawa Island Project in Indonesia

The GIPE++ 2025 Project on Untung Jawa Island, Indonesia, focused on "Establishing a Digital Platform for Conservation and Tourism Development." Partnering with the community organization Pokdarwis, the project addressed critical gaps in digital presence, promotional creativity, business strategy, and coastal abrasion monitoring.

To tackle these issues, an international team from Germany, Indonesia, Namibia, and Peru—spanning IT, Environmental Engineering, Business, Communication, and Tourism—collaborated from March to July 2025. Participants worked in specialized "streams" to produce four deliverables which are: (1) A dedicated tourism website, (2) A business development strategy, (3) Innovative new media, (4) promotional content, (5) Baseline environmental data reports.

The stream selection process highlighted two distinct Cultural Motivation Styles (Samovar et al., 2017): (1) Learning When Interested, many students chose streams matching their academic expertise and (2) Intrinsic Motivation, where significant numbers of students joined unfamiliar disciplines to acquire new skills and contribute meaningfully.

Supported by Stream Leads and experts, these teams navigated complex intercultural dynamics. The project concluded in July 2025 with a formal handover to the client, successfully blending diverse cultural perspectives and academic disciplines through the essence of intercultural project-based learning.

6. Discussion

The longitudinal analysis of GIPE and GIPE++ (2020–2026) demonstrates that the future of internationalisation must transcend mobility metrics to embrace models of collaborative responsibility and tangible societal impact. Findings suggest that Intercultural Project-Based Learning (IPBL) serves as a robust educational paradigm, equipping students to navigate contemporary global complexities where traditional, passive exposure models fail. This shift aligns with the broader movement toward integrating sustainable development goals within higher education curricula to foster systemic thinking (Leal Filho, Shiel, & Paço, 2016). Critical to this growth is the concept of productive intercultural friction. While institutional frameworks often attempt to mitigate conflict, the GIPE experience reveals that facilitated tension, arising from divergent communication styles and cultural expectations, acts as a fundamental driver of innovation and resilience. This validates the premise that inherent tensions in professional and disciplinary diversity can be leveraged to enhance collaborative outcomes (Dahlberg, Sitter, Woody, & Ketcher, 2025). In the case of Pulau Untung Jawa, these frictions transformed diversity from a symbolic attribute into an operational necessity, forcing students to reconcile conflicting values while co-designing sustainability strategies.

The study validates the efficacy of the “Sandwich Model” of blended mobility. The integration of virtual collaboration with intensive physical immersion, specifically the Spring School in Germany, functioned as a relational accelerator, transforming fragmented digital teams into cohesive communities. This ecosystem proves that physical encounters are most effective when embedded as catalysts within long-term collaborative processes rather than as isolated events (Beelen & Jones, 2015). Such models effectively advance "Internationalisation at Home" by embedding global sustainability challenges directly into institutional identities, ensuring that intercultural learning is accessible beyond the mobile minority.

Although the implementation of IPBL demands significant organisational flexibility and robust facilitation to manage the cognitive demands of transnational teamwork, its potential for scaling is evident. Ultimately, the GIPE initiative argues for a shift in higher education: moving beyond the production of "globally mobile professionals" toward the cultivation of socially responsible agents of transformation capable of co-creating equitable futures under real-world constraints.

7. Conclusions

The longitudinal evidence from the GIPE and GIPE++ initiatives (2020–2026) demonstrates that Intercultural Project-Based Learning (IPBL) serves as a vital pedagogical evolution, moving higher education beyond traditional mobility metrics toward a model of substantive societal impact. By integrating real-world sustainability challenges with interdisciplinary co-creation, IPBL transforms intercultural competence from a theoretical concept into an operational necessity, where productive intercultural friction acts as a primary driver for innovation, resilience, and ethical adaptability. The success of the blended Sandwich Model further demonstrates that global engagement can be structurally embedded within institutional identities, fostering a scalable form of internationalisation at home. Ultimately, this framework redefines the role of the university in the twenty-first century, transitioning from the production of globally mobile professionals to the cultivation of socially responsible agents of transformation capable of navigating complex, transnational crises through collaborative action.

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MOBILE, MEANINGFUL AND INCLUSIVE: RETHINKING ONLINE COURSE DESIGN FOR DIVERSE STUDENT POPULATIONS

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Abstract

As institutions serving increasingly diverse student populations expand their online offerings, course design must move beyond general best practices to intentionally address the needs of underrepresented students. Metropolitan State University of Denver (MSU Denver), a federally designated Hispanic-Serving Institution, enrols a student population that is 56.9% students of color and 53.2% first-generation college students. These demographics underscore the urgent need for inclusive, equity-focused online course design that supports persistence, confidence, and academic success. This paper presents an integrative framework for online course development grounded in the authors' extensive teaching experience at MSU Denver. Drawing from institutional context and applied instructional practice, the authors identify key design and instructional strategies that enhance access, engagement, and retention among ethnically and economically diverse learners. These strategies include: (a) optimizing courses for mobile and handheld device access; (b) providing clear, structured timelines and intuitive course organization; (c) emphasizing conceptual, application-based assessments over rote memorization; (d) embedding a course-specific online orientation; (e) fostering consistent and meaningful student–instructor interaction; (f) incorporating reflective blogging to personalize learning; and (g) limiting mandatory group projects that may create barriers related to time, work obligations, or social anxiety. Mobile optimization supports students who rely primarily on smartphones or tablets due to financial constraints. Clear timelines and structured organization help mitigate challenges associated with self-regulation, which may disproportionately affect first-generation and underprepared students. Course-specific orientations increase technological confidence by allowing students to practice essential tasks such as discussion participation, quiz completion, video engagement, and assignment submission within a low-stakes environment. Shifting assessments from memorization to conceptual understanding reduces inequities associated with prior academic privilege while promoting deeper learning. Finally, consistent instructor presence and opportunities for reflective engagement foster belonging, connection, and academic integration. Collectively, these practices represent an integrative, equity-driven approach to online course design. By intentionally aligning pedagogy, technology, and assessment with the lived realities of underrepresented students, faculty can enhance retention, academic confidence, and overall student success in online learning environments.

Keywords: *Online course design, equity-focus pedagogy, student retention.*

1. Introduction

Online education is often promoted as a flexible pathway for students whose lives do not fit traditional campus-based schedules. Yet flexibility alone does not guarantee equity. For many students, particularly first-generation learners, students from economically constrained backgrounds, adult learners, and students of color, online courses can either reduce barriers or reproduce them in new digital forms. A course may be technically online but still difficult to navigate on a phone, confusing in its organization, dependent on hidden academic expectations, or built around assessment practices that reward prior academic privilege more than meaningful learning. In equity-focused online design, the central question is not simply whether course content is available online, but whether the course structure, communication patterns, assessments, and technology expectations align with the lived realities of the students being served.

This issue is especially important at Metropolitan State University of Denver (MSU Denver), a federally designated Hispanic-Serving Institution. Current institutional reporting shows that 56.9% of MSU Denver undergraduates are students of color, Hispanic students represent the largest undergraduate group at 37%, and 53.2% of students are first-generation college students (Metropolitan State University

of Denver, 2025). These demographics are not merely background information; they are design mandates. Online courses serving this population must be intentionally structured to support persistence, belonging, confidence, and academic success. Drawing from applied teaching experience and the broader literature on online learning, this paper proposes an integrative framework for designing online courses that are mobile, meaningful, and inclusive.

2. Equity as a design principle

Equity in online learning requires attention to access, participation, and outcomes. Tate and Warschauer (2022) argue that digital inclusion is shaped not only by physical access to devices and connectivity, but also by human and social resources that influence how students use digital tools for learning. This distinction is critical. A student may technically have access to a learning management system but still struggle if course materials are not mobile-friendly, instructions are difficult to interpret, deadlines are scattered across multiple locations, or instructor support is inconsistent. Equity-focused design therefore requires faculty to anticipate structural barriers rather than respond only after students fall behind.

One practical implication is that online courses should be designed from the beginning for mobile and handheld access. Research on student-initiated mobile device use in online courses shows that students use phones and tablets for convenience, portability, communication, reading, downloading materials, and completing course-related tasks, even when those devices create limitations compared with laptops or desktop computers (Milheim et al., 2021). For students who rely on shared technology, public Wi-Fi, long commutes, or work breaks, mobile access is not a convenient feature; it may be the difference between staying engaged and disappearing from the course. Mobile-responsive design includes readable documents, short videos with captions, clear module structures, accessible PDFs, streamlined navigation, and assignments that do not require unnecessary software or large-screen formatting unless essential to the learning outcome.

3. Structure, orientation and self-regulated learning

Online learning requires students to manage time, motivation, help-seeking, task planning, and self-monitoring. These self-regulated learning skills are associated with success in online environments, but faculty cannot assume that students develop them simply by enrolling in online courses. Wandler and Imbriale (2017) emphasize that instructors can promote self-regulated learning through intentional course design, including clear expectations, structured supports, opportunities for planning, and prompts that encourage students to monitor their progress. For first-generation and underprepared students, such scaffolding is not remedial; it is transparent teaching.

Clear timelines and intuitive organization are therefore central to inclusive online design. Students should not need to search multiple locations to determine what is due, when it is due, and how it will be evaluated. Modules should follow a predictable rhythm, such as overview, learning objectives, readings or videos, practice activity, discussion or reflection, and assignment submission. A course-specific online orientation can further reduce uncertainty by allowing students to practice essential tasks in a low-stakes environment: posting to a discussion, submitting an assignment, completing a quiz, viewing feedback, accessing captions, and locating instructor contact information. This orientation is particularly valuable because many online learning challenges arise not from lack of ability, but from lack of familiarity with course-specific expectations and digital routines.

4. Meaningful assessment and instructor presence

A second design commitment is to emphasize conceptual and application-based assessment rather than overreliance on memorization. In counseling, human services, behavioral health, and other practice-oriented fields, students must be able to apply concepts to real-world ethical, cultural, relational, and systems-based situations. Application-based assignments, case examples, reflective responses, scenario analyses, and scaffolded projects can better capture students' developing knowledge, attitudes, and skills than exams focused primarily on recall. This approach also reduces inequities associated with prior academic privilege because it creates multiple ways for students to demonstrate understanding through practice, reflection, and integration.

Instructor's presence is equally important. The Community of Inquiry framework identifies teaching presence, social presence, and cognitive presence as central elements of meaningful online learning (Garrison et al., 2000). Teaching presence includes design, facilitation, and direction; it is

experienced by students through clear organization, timely communication, feedback, announcements, and visible instructor engagement. Fiock (2020) offers practical strategies for designing online courses around this framework, emphasizing that presence can be built through intentional design choices rather than constant synchronous meetings. For faculty, this distinction matters. Inclusive online courses do not require faculty to be available at all hours; they require predictable, meaningful, and accessible interaction. Weekly announcements, short video or written check-ins, timely grading patterns, rubric-based feedback, optional office hours, and responsive email practices can create connection while preserving sustainable faculty workload.

5. Reflection, belonging and flexible engagement

Reflective activities can personalize online learning and strengthen students' sense of connection to course material. Blogs, reflective journals, and discussion-based reflections ask students to connect theory to lived experience, professional identity, ethical decision-making, and community context. Halic et al. (2010) found that blogging in an undergraduate course had the potential to support reflection, collaboration, and perceived learning, particularly when students experienced a sense of community. In equity-focused online courses, reflective blogging can help students see their experiences as legitimate sources of insight while also practicing professional communication and critical thinking.

At the same time, inclusive design requires careful attention to group work. Collaboration can be valuable, but mandatory online group projects may create barriers for students balancing work, caregiving, transportation challenges, health concerns, social anxiety, or inconsistent access to technology. A systematic review of online group projects found that such assignments create recurring challenges related to communication, coordination, unequal participation, and technology use (Donelan & Kear, 2024). This does not mean group work should be eliminated. Rather, it should be used intentionally when collaboration is central to the outcome, supported with clear roles and timelines, and balanced with individual alternatives or accountability structures when appropriate. In many online courses, students can still engage with peers meaningfully through structured discussions, peer feedback, shared resource boards, or optional collaborative activities without making high-stakes group projects the core determinant of success.

6. An Integrative framework for inclusive online course design

The framework proposed here brings these practices together through seven design commitments. First, courses should be mobile-responsive so that students using phones or tablets can access core materials without unnecessary barriers. Second, courses should use clear, consistent timelines and module structures to support self-regulation. Third, each course should include a low-stakes orientation that builds confidence with the specific learning management system tasks required for success. Fourth, assessments should prioritize conceptual understanding, application, and professional judgment. Fifth, instructor presence should be consistent and meaningful but sustainable, using predictable communication and feedback practices. Sixth, reflective assignments should be incorporated to personalize learning and support belonging. Seventh, mandatory group work should be limited or carefully scaffolded so that collaboration supports learning rather than creating avoidable obstacles.

These practices are especially important for programs preparing students for counseling, human services, behavioral health, and related fields. Students are not only learning content; they are developing professional identity, cultural humility, ethical awareness, and applied judgment. An online course that model's clarity, responsiveness, flexibility, and inclusion teach more than the stated curriculum. It communicates what it means to create accessible and respectful learning environments, and it demonstrates the same values students will be expected to carry into professional practice.

7. Conclusion

Equity-focused online course design must be intentional, practical, and grounded in the realities of diverse student populations. For institutions such as MSU Denver, where large numbers of students are first-generation, students of color, transfer students, working adults, and community-connected learners, online courses must do more than place content into a digital shell. They must be structured to reduce hidden barriers, strengthen confidence, support belonging, and promote meaningful application. Mobile access, clear organization, orientation, application-based assessment, instructor presence, reflective engagement, and intentional use of collaboration provide a practical framework for this work. Ultimately, inclusive online design is not separate from academic rigor. It is the pathway through which rigor becomes accessible, meaningful, and sustainable for the student's higher education is called to serve.

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THE USE OF MOBILE CLICKER TECHNOLOGY IN FOUNDATIONAL ORGANIC CHEMISTRY FOR ENHANCED STUDENT ENGAGEMENT

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Abstract

Foundational Organic Chemistry is typically taught in the final quarter of the second semester, a period when students often experience reduced concentration and energy levels. Engaging students in this context remains a persistent challenge, particularly given the abstract nature of the content and the high cognitive demands associated with the subject. This study explores the integration of mobile clicker technology as a pedagogical strategy to foster an interactive, inclusive, and responsive learning environment in large classroom setting at a traditional contact university in Pretoria, South Africa. The intervention involved the strategic incorporation of five to six clicker questions within the lecture to stimulate critical thinking, identify learning gaps, and promote collaborative engagement. By using their personal mobile devices, students engage in real-time learning through immediate feedback and lecturer-facilitated discussions aimed at addressing misconceptions. A mixed-method approach was adopted. Quantitative data were obtained from student performance on subtopic-specific questions embedded within lectures, as well as from a comprehensive integrative quiz administered at the conclusion of the topic. Qualitative data were drawn from students' feedback collected through end-of-course teaching evaluations. A pre-test and post-test were also conducted to measure knowledge gained. The findings of this study show that the use of mobile clickers enhanced student engagement, as evidenced by higher participation rates and continued attention during lectures. Students reported improved confidence in navigating complex concepts and valued the immediate feedback. Additionally, the technology fostered a more inclusive learning environment by enabling anonymous participation, thereby supporting contributions from less vocal students. Furthermore, performance on the integrative quiz suggests improved consolidation of knowledge across subtopics. Overall, although mobile clickers have their limitation, the study highlights their value as an effective pedagogical tool in transforming passive learning environments into active, student-centred spaces and recommends their integration in science education.

Keywords: *Mobile clickers, foundational organic chemistry, pedagogical strategy, student engagement, active learning.*

1. Introduction

Academic performance varies significantly among students due to differing abilities, socio-economic backgrounds and circumstances. Unfortunately, not all students get good academic marks at the end of High School and are thus not adequately prepared for university. Access programmes have been designed by many universities across South Africa to accommodate these type of students (Rollnick *et al*, 2010). Extended Curriculum Programmes (ECPs) have been designed at the study university to grant access to students who have scored lower admission point score (APS) than the minimum required for the mainstream programmes. The aim of the ECPs is to bridge the gap between school and university within a year, allowing the students to strengthen the foundational knowledge, which helps with the transition from secondary to tertiary education.

At the study University, the curriculum structure of the Bachelor of Science (BSc) ECPs, is composed of two fundamental modules, including Language and Study Skills and Academic Information Management (basic computer literacy), and five foundational modules, namely, Biology, Chemistry, Mathematics, Physics and Statistics. The aim of the ECPs is to enhance students' basic knowledge, critical thinking and academic skills. It is expected of students starting their study journey in the ECPs to

become more confident and competent at the end of the first year, thus being able to perform at the pace required of mainstream university students.

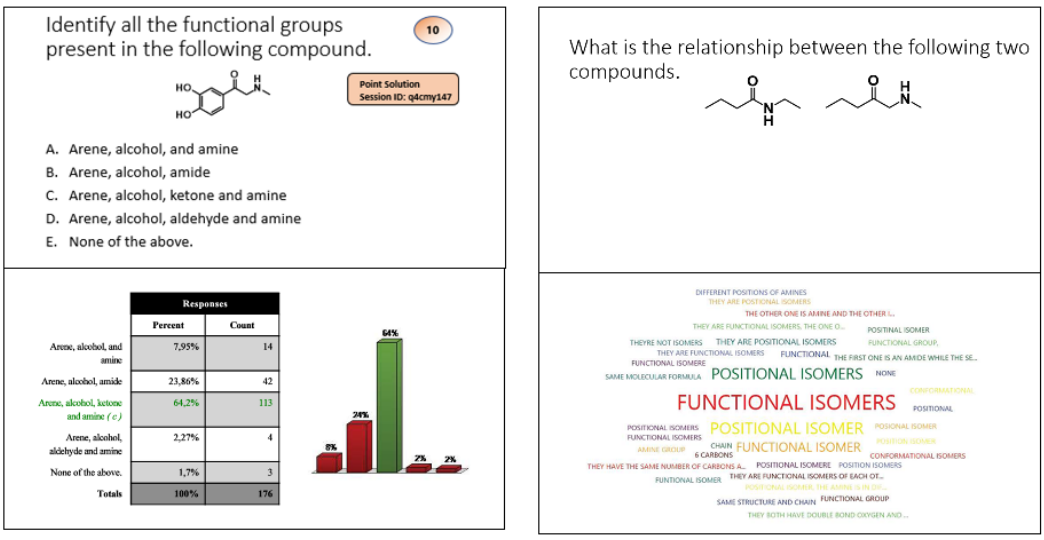
Two Chemistry modules are offered to the ECPs students in their first year; General Chemistry topics offered in the first three quarters and Organic Chemistry in the last quarter. Research has shown that Organic Chemistry is a challenging course with a high failure and dropout rate (Grove *et al*, 2008; Petritis *et al*, 2022; Salame *et al*, 2023). Organic Chemistry requires one to think abstractly, recognise patterns and understand cumulatively, with each concept building on prior knowledge. Foundational Organic Chemistry is unfortunately taught during the last quarter of the semester after months of sustained academic effort, academic pressure and tighter deadlines and the students often experience reduced concentration, motivation and energy levels. Engaging students under these circumstances remains a persistent challenge, particularly given the abstract nature of the content and the high cognitive demands associated with the subject. Teaching approaches should be designed to re-engage students and develop their confidence to tackle complex problems. The university teaching model requires of the lecturer to prepare and activate before class, engage actively during class and consolidate after class whereas for its learning philosophy, it requires of students to prepare and get ready before class, engage and participate during class and practice and reflect after class. This study explores the integration of mobile clicker technology as a pedagogical strategy to foster an interactive, inclusive, and responsive learning environment in large classroom setting which aligns well with the teaching and learning philosophy of the study university.

2. Design

The intervention involved the strategic incorporation of clicker questions in the teaching to stimulate critical thinking, identify learning gaps, and promote collaborative engagement. An ideal research design would involve the same lecturer teaching the same topic in parallel classes. The lecturer uses the mobile clicker in one class and conducts normal lectures in the parallel class in a traditional university setup. Unfortunately, one cannot implement this design model in the ECPs as a difference will be created between groups that are supposed to receive full support in their first year of study.

Both multiple-choice and short-answer questions, as shown in Figure 1, are asked during a lecture as a strategy for consolidation and monitoring of students' understanding of the topic under discussion. Five to six clicker questions are embedded in each lecture session to check understanding and support active learning. The students download the PointSolutions application and respond anonymously using their mobile devices. Their responses are displayed instantly and are used to guide discussion and clarification of the misconceptions. Based on the output, topics are revisited to ensure that all the students have grasped the concept, aligning very well with the university's model of teaching and learning. A pre-test is conducted using the clicker technology to assess the knowledge gained after the initial teaching of a concept. A post-test is conducted after addressing the misconceptions noted in the pre-test. This enables the researcher to evaluate any improvement based on the students' responses.

Figure 1. Multiple-choice and short- answer questions using the clicker technology with their responses displayed below the questions.



3. Objectives

The objective of this study is to examine the extent to which mobile clicker technology enhances student engagement and understanding and the degree to which the used technology supports the attainment of the learning outcomes within a traditional lecture setting.

The study explores how the incorporation of a few multiple-choice and short- answer clicker questions throughout lectures could prompt higher order thinking, hence enhancing students' basic knowledge and academic skills in a foundational Organic Chemistry

4. Methods

A mixed-method approach was adopted to evaluate the intervention comprehensively. Quantitative data were obtained from students' performance on subtopic-specific questions spaced within the lecture slides, as well as from a comprehensive integrative quiz administered at the conclusion of the topic, as shown in Figure 2. Qualitative data were drawn from the university driven students' feedback on the teaching survey (SFTS) collected at the end of the semester. Table 1 contains an excerpt from the 2025 students cohort feedback.

Figure 2. Top: Integrative quiz administered at the conclusion of the topic;
Bottom: Integrative quizzes administered after a specific topic was covered.

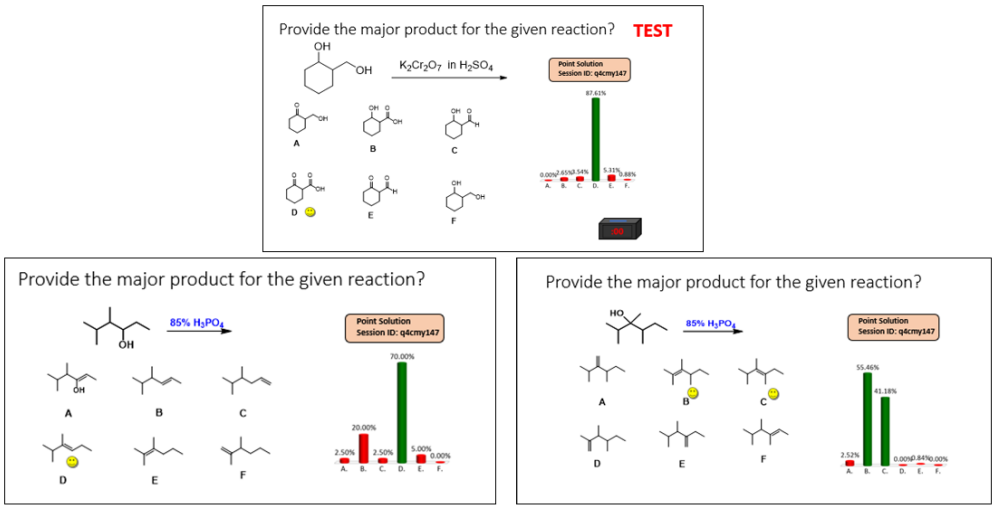


Table 1. An excerpt from the 2025 students' feedback collected at the end of the semester.

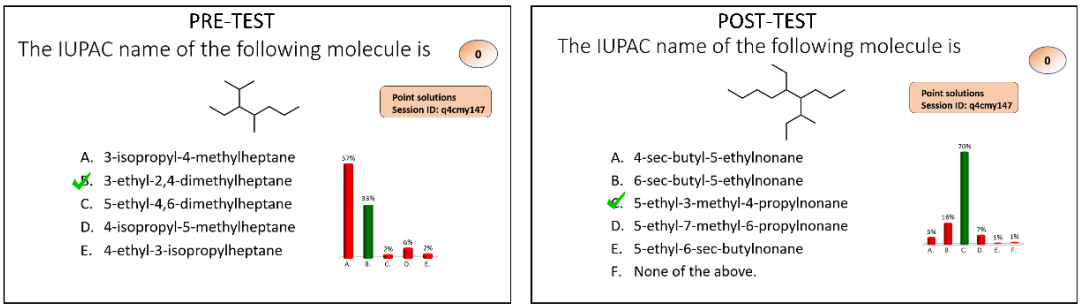
Question: What did you like most in this module?
I really did enjoy doing Organic chemistry with Dr PB. She made the classes interactive and we could really participate in the discussions
The lecturer gave us an opportunity to do clicker questions after explaining the work, which ensured that we were on the same page.
The point solutions activities in class were really helpful
The teaching pace was perfect and I was able to understand most of the work given to me without having to consult with videos on YouTube.
She made students to engage in class which made us to understand more and gave us work problems that prepared us well.
she engages with the students and she made chemistry fun and interesting to learn.
I liked how she would make us engage in class with class activities and clickers. This helped to understand the content much better.
Dr PB prepared lectures that allowed for me to fully engage with and grasp the content being covered. Further studying was therefore simpler as only revision and practice was needed.
The teaching method was beneficial to me and this showed in my marks.
I really liked the way Miss PB interacted with the class. She made classes interesting and interactive.

5. Discussion

The findings of this study showed that the use of mobile clickers in the foundational Organic Chemistry class at the study university had a positive impact on classroom dynamics and students' learning, with high pass rate at the final examination. Research carried out by Ward and co-workers (Ward *et al*, 2017) showed that the presence of one's smartphone can reduce available cognitive capacity. They also showed that students who kept their phones on their desk while studying, did not perform in their tests. However, the use of mobile clickers in class, and in this study, appears to contradict their findings. By using the mobile phone in a constructive way, changes the perceived view of a source of distraction into a learning tool that enhances learning.

Mobile clickers can be used to quickly identify misconceptions in class, allowing the lecturer to correct them before it becomes deeply rooted in the students'mind. As illustrated in Figure 3 (left), many students did not recognise that the parent name corresponds to the longest chain with the highest number of substituents. This misconception was identified in the pre-test, given to students after initial teaching of nomenclature using the IUPAC rules, and addressed immediately. A similar clicker question was asked in the post-test and the data in Figure 3 (right) showed that actual learning took place.

Figure 3. Left: Pre-test given to students after initial teaching of a topic was done; Right: Post-test given to students after misconception from the pre-test was addressed.



This study also show that the use of mobile clickers enhanced student engagement, as evidenced by high participation rates and sustained attention during lectures. Students who are generally shy do not participate in a traditional classroom setting. Since the PointSolutions Application allows students to respond anonymously, they do not hesitate to participate. There is a noticeable increase in inclusivity and a better overall learning experience. Furthermore, the course achieved a higher pass rate in the final examination (91%), indicating the success of the intervention.

Since this study relies on self-reported data, the findings may be subject to bias. However, the students' feedback collected from the teaching evaluations indicates that the use of mobile clickers in class was perceived as highly beneficial to their learning experience.

One of the main limitations of mobile clickers is the dependence on reliable internet connectivity and mobile device functionality. Unstable Wi-Fi and phone battery depletion can disrupt participation and consequently, reduce the effectiveness of the implemented strategy.

6. Conclusions

This study demonstrates that mobile clickers are an effective instructional tool for the ECPs students. They promote active learning, increase students' engagement and provide immediate feedback during lectures. In foundational Organic Chemistry, their use as a pedagogical tool transforms passive learning environments into active ones, even in periods when students often experience reduced concentration and energy levels. Although mobile clickers have limitations, they can significantly enhance the learning environment when used appropriately. Their integration is therefore recommended in science education.

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POSTERS

HANDS-ON PHYSICS: EXPERIMENTAL TEACHING FROM PRIMARY TO TERTIARY EDUCATION

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Abstract

The Erasmus+ project "Lexicon of STEM Educational Films for Primary and Secondary School Students" (Films4Edu) aimed to enhance the quality and reach of distance education in STEM disciplines at the primary and secondary school levels. Implemented across four countries and six partner institutions: University of Silesia in Katowice (Poland), University of Innsbruck (Austria), University of Málaga (Spain), Children's University of Malopolska Foundation (Poland), AGH University of Science and Technology (Poland), and the University of Žilina (Slovakia), the project focused on developing innovative audiovisual teaching resources.
This contribution presents selected educational videos produced at the University of Žilina and examines their potential integration into STEM curricula in primary and secondary education.
We are currently continuing our work within the new Erasmus+ project "Experiments for Better Teaching in Higher Education" (expEDU). The project aims to foster more interconnected higher education systems by building an international community of science educators who collaboratively share knowledge, resources, experiences, and best practices in physics experimentation. This collaborative framework strengthens the capacity of partner institutions to work more effectively together, ultimately contributing to improved educational outcomes. The main priority of the project is to stimulate innovation in teaching and learning by supporting pedagogical experiments and introducing new approaches to teaching in higher education.
During the presentation, we will outline the project's objectives, explore opportunities for further cooperation, and discuss ways to participate in the initiative. In addition to the University of Žilina (UNIZA, Slovakia), the participating institutions include the University of Silesia in Katowice (Poland), VSB – Technical University of Ostrava (Czech Republic), and Ivan Franko National University of Lviv (Ukraine).

Keywords: *STEM education, interactive teaching of physics, educational films, Films4Edu, expEDU.*

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1. Introduction

The specific objectives of the Films4Edu project were to enhance the knowledge and competencies of primary and secondary school teachers in the use of film-based experimental approaches in STEM education; to increase primary and secondary school students' interest in physics and chemistry experiments; to strengthen the understanding of dissemination activity beneficiaries regarding the educational opportunities afforded by film-based experimental methodologies in STEM; and to foster innovation and internationalization among the six participating institutions through the exchange of best practices, the joint development of universally applicable educational and training materials, and the promotion of open education.

2. Methodology

The project produced several intellectual outputs, including a *Methodology for Teaching STEM Subjects through Film4Edu Experiments*, an *Online Catalogue of Physics Experiments for Primary and Secondary Schools*, and an *Online Catalogue of Chemistry Experiments for Primary and Secondary Schools*. The developed scenarios highlight two primary functions of experiments: a methodological function, whereby experiments serve as a source of knowledge and a means of verification, and a didactic function, encompassing introductory experiments designed to create problem-based learning situations,

cognitive experiments that facilitate knowledge acquisition, verification experiments used to test hypotheses, and illustrative experiments aimed at demonstrating phenomena and validating scientific laws.

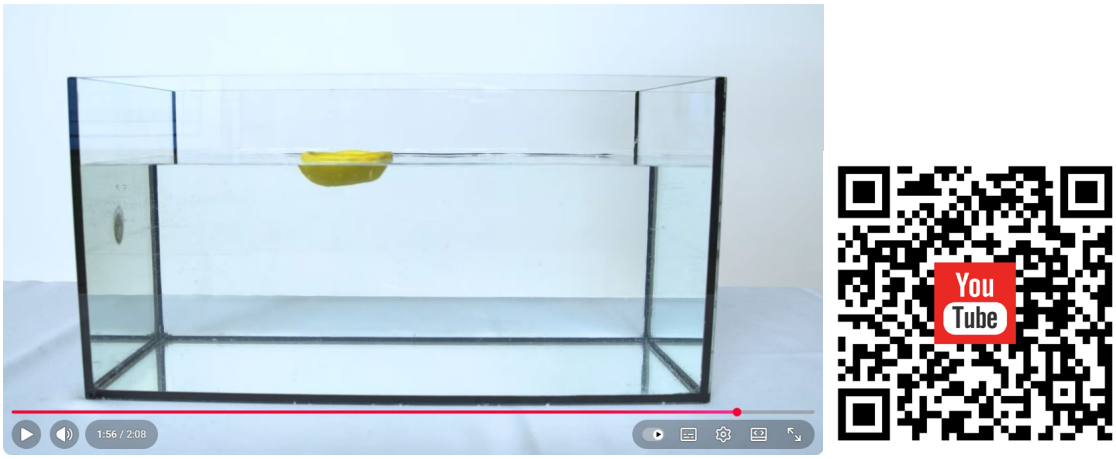
3. Results

As an outcome of the project, European primary and secondary school teachers gained access to a comprehensive collection of didactic videos presenting physics and chemistry experiments, which can be integrated into face-to-face instruction as well as online teaching environments. For each recorded experiment, an accompanying worksheet was developed, providing a detailed description of the experimental procedure, a scientific explanation of the underlying physical or chemical phenomena, and a clear indication of the target educational level. In addition, each video is supplemented with formative assessment questions that enable teachers to evaluate students' conceptual understanding of the experimental principles. Overall, the project resulted in the production of more than 100 didactic videos in physics and chemistry, which are publicly available through the Films4Edu YouTube channel: https://www.youtube.com/@films4edu607/videos.

3.1. Floating objects - one of 100 experiments and videos from Films4Edu

The primary objectives of this video (Figure 1) are to analyze the physical properties of liquids and to facilitate conceptual understanding of Archimedes' principle. The experiment is motivated by the observation of natural phenomena, such as bodies floating on or sinking in a liquid. The instructional focus is on elucidating the conditions under which an object floats or sinks, identifying the parameters that determine the magnitude of the buoyant force, and examining the possibility of objects with densities greater than that of water remaining afloat on the liquid surface. The video has a duration of 2 min 8 s and is available on the Films4Edu YouTube channel: https://youtu.be/9mCHM2_G6lE.

Figure 1. Filns4Edu video - Floating Objects | FLUIDS and QR code for more videos.



4. Discussion

Information and communication technologies (ICT) in physics education contribute significantly to enhancing the effectiveness of the teaching and learning process. Motivation to engage in STEM (Science, Technology, Engineering, and Mathematics) disciplines typically emerges during primary education or earlier; therefore, early intervention is essential for achieving positive long-term educational outcomes. In response to this need, the Children's University of Žilina (CUZ) has been implemented as a summer educational program for primary school pupils. Questionnaire-based feedback from participating children indicates a strong demand for a greater number of experimental demonstrations, more extensive use of multimedia resources, and instructional approaches that foster imagination, creativity, and collaborative skills (Hockicko et al., 2020, 2025). Developing students' imaginative capacity and analytical thinking has been shown to enhance interest in natural sciences and technological subjects (Hockicko et all, 2025). Within this context, teachers and researchers from the University of Žilina have sought to stimulate young learners' motivation for future studies in science and technology through the organization and delivery of the Children's University of Žilina (Figure 2).

Figure 2. Experimental activities implemented during the Children's University of Žilina after watching the video.

As reported in our previous study (Hockicko et al., 2020, 2025), analysis of questionnaires completed by children over 15 years of the CUZ summer program indicated that primary school students prefer lessons that are more playful, include a greater number of practical demonstrations and experiments, and provide opportunities for hands-on laboratory activities, with 47% (Hockicko et al., 2020, (46% (Hockicko et al., 2025)) of respondents expressing interest in conducting experiments independently.

The educational videos developed within the Films4Edu project have the potential to further motivate young students to engage in experimental activities and serve as a valuable resource for primary and secondary school teachers in designing and implementing effective, student-centered laboratory exercises.

The new project expEDU seeks to enhance the integration of higher education systems through the establishment of an international network of science educators dedicated to the exchange of knowledge, resources, experiences, and best practices in physics and chemistry experimentation. This collaborative framework strengthens inter-institutional cooperation and improves the collective capacity of partner institutions to implement effective educational strategies, thereby contributing to enhanced learning outcomes. A central objective of the project is to promote innovation in teaching and learning by supporting pedagogical experimentation and the adoption of novel instructional approaches in higher education. As a key output, the project will produce 80 experimental physics and chemistry video resources, accompanied by comprehensive instructional guidelines for educators and made available in multiple languages.

5. Conclusions

Empirical evidence indicates that the use of instructional videos demonstrating fundamental physics concepts, when complemented by video analysis and guided discussion, leads to significant improvements in students' conceptual understanding and knowledge acquisition in Newtonian mechanics. Consequently, we are continuing to develop additional instructional videos aimed at further enhancing the effectiveness of physics instruction in higher education.

Acknowledgments

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WEARABLE-ASSISTED TASK SUPPORT FOR CHILDREN WITH AUTISM SPECTRUM DISORDER IN EDUCATIONAL CONTEXTS

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Abstract

Children diagnosed with Autism Spectrum Disorder (ASD) often experience difficulties maintaining attention and completing daily routines independently. This paper presents a wearable-based support system aimed at enhancing autonomy and task-sequencing skills through two synchronized applications for Apple Watch and iPhone. Developed with Apple native tools, the system features interfaces and pictographic elements. Generative artificial intelligence (AI) assists caregivers and educators in automatically decomposing tasks into personalized, step-by-step routines displayed on the smartwatch. The system was validated through a mixed-method study involving educators and families from local ASD support associations. Evaluation included functional and usability testing across multiple devices, as well as a Likert-based satisfaction survey. Results indicate that wearable visual cues positively influenced children's engagement with everyday tasks, increasing predictability and reducing stress. These findings highlight the potential of accessible wearable technologies to support autonomy and participation in inclusive education, with ongoing work focused on adaptive feedback, customizable visuals, and classroom-oriented analytics.

Keywords: *Inclusive education, wearable technology, task management, assistive applications, ASD.*

1. Introduction

In inclusive education, supporting autonomy in daily routines is a practical and pedagogical priority for many children with ASD, especially when sustained attention, planning, and transitions affect participation (American Psychiatric Association, 2013). Educational practice frequently relies on structured prompts, visual supports, and stepwise task guidance to reduce uncertainty and support engagement across classroom and home contexts. However, these supports are not always available at the point of need, can depend on adult mediation, and may be difficult to generalize across settings.

Wearable devices provide an opportunity to deliver discreet, always-available prompts that travel with the learner, potentially strengthening continuity between school and family routines. To operationalize this potential, this paper presents an education-oriented intervention: a synchronized Apple Watch–iPhone system that externalizes routines into short, pictographic prompts and logs outcomes for reflective follow-up (Cooper et al., 2020).

This paper is organized as follows. Section 2 shows the educational objectives of this proposal. The intervention design is explained in Section 3, and Section 4 is devoted to methods for this work. Finally, Section 5 gives some results and a brief discussion about them, while the main conclusions are presented in Section 6.

2. Educational objectives

The intervention is designed to support competencies commonly addressed in individualized and inclusive education programs:

i. Autonomy and task completion, by reducing reliance on adult prompting.
ii. Task-sequencing and executive functioning, by presenting routines as small, manageable steps.
iii. Predictability and emotional regulation, by clarifying what is happening now and what comes next.
iv. School and family coordination, by enabling shared routine definitions and consistent supports across contexts.
v. Data-informed adjustment, through simple indicators (completion, help requests, time usage) that guide educators' and families' reflective practice without shifting the focus to surveillance.

3. Intervention design

The system consists of two synchronized applications. The Apple Watch app is learner-facing: it provides routine prompts and step-by-step guidance using pictographic supports. The iPhone app is adult-facing: it enables educators and caregivers to define routines, select pictograms, and review basic interaction outcomes.

3.1. Learner-facing interaction on Apple Watch

The Apple Watch interface is designed to minimize cognitive load: it prioritizes large pictographic cues (ARASAAC, 2026) and short, consistent interaction patterns. Each routine is presented as a sequence of steps, with a strong emphasis on immediate clarity ("what to do now"). The smartwatch delivers cues discreetly, supporting participation without drawing unnecessary attention. A central design decision is the use of short visual prompts to improve predictability. Predictability is treated as an instructional scaffold: when routines are clear and consistent, children may experience greater control during transitions, which can improve cooperation and reduce stressors associated with ambiguous instructions.

A playful "coin" micro-interaction was added to increase engagement without adding navigational complexity: a short tap on the circular progress element triggers a 3D rotation animation. On the reverse side, the interface displays concise task metadata (task name in uppercase and start/end times using symbols and numbers), providing additional information while preserving low-text interaction (see Figure 1).

Figure 1. Coin-like flip interaction used to reveal task metadata on Apple Watch.

3.2. Adult-facing authoring and follow-up on iPhone

The iPhone app supports routine authoring by educators and families, allowing them to create personalized, step-by-step sequences and associate each step with pictographic elements. It also provides a lightweight review of outcomes based on watch interactions (e.g., completion results and help requests), enabling adults to adjust routines pragmatically (step granularity, time allocation, or reinforcement strategies).

4. Methods

The following subsections describe the development approach and mixed-methods validation.

4.1. Development approach and accessibility principles

The intervention was developed in collaboration with a local association supporting children with ASD in A Coruña, Spain. Guided by Universal Design for Learning principles, which emphasize reducing access barriers and providing multiple means of representation (CAST, 2018), interface decisions prioritized pictographic supports, reduced text dependence, and stable interaction patterns.

4.2. Generative AI for task decomposition

To support educators and caregivers in creating effective stepwise routines, tasks were automatically decomposed with the assistance of generative AI. The educational intent of this component is practical: it helps adults convert broad activities into developmentally appropriate steps that can be reviewed and refined by the educator/caregiver, improving feasibility and consistency of routine authoring. This approach also promotes autonomy for the smartwatch user by enabling an automated help mode based on pictographic prompts, allowing the child to access step-by-step support discreetly and with reduced reliance on adult intervention.

4.3. Mixed method validation

A mixed-method validation was conducted with educators and families through collaborating associations. The evaluation combined:

i. Functional and usability testing across multiple iPhone and Apple Watch models to confirm operational robustness and consistent interaction.

ii. A Likert based satisfaction survey to capture perceived usability and educational value. Qualitative feedback was additionally collected to identify improvements relevant to diverse learner profiles and authentic classroom/home constraints.

5. Results and discussion

Findings indicate that wearable cues positively influenced how children approached everyday tasks, as reported by educators and families. By externalizing routines into short, visual prompts, the system increased predictability and control, which was associated with reduced stress and improved cooperation in learning and domestic activities.

From an educational perspective, this suggests that the intervention's value is not solely in reminding, but in providing an accessible "external executive scaffold" that supports task initiation and step transitions. The wearable format also supports continuity across contexts: routines follow the learner rather than being tied to a pictogram-based wall schedule or an adult's phone.

The ASD local association feedback emphasized the importance of personalization. Because ASD profiles are heterogeneous, the visual vocabulary and step granularity vary by age, preferences, and sensory or cognitive needs. The system's reliance on pictograms is beneficial for many learners, but adults requested flexibility to adapt visual sets and levels of detail.

6. Conclusions and educational implications

This study presented an education-focused, wearable-based routine support system integrating synchronized Apple Watch and iPhone applications to enhance autonomy and task sequencing for children with ASD. The pilot validation with educators and families supports the pedagogical relevance of visual wearable prompts as mediators of predictability, participation, and reduced routine related stress.

For inclusive education practice, the work suggests three practical implications: (i) wearable prompts can reduce dependence on adult mediation at the point of need, (ii) stepwise routines can function as a scalable instructional scaffold across settings, and (iii) lightweight outcomes enable reflective routine tuning without imposing high documentation burden.

Acknowledgments

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EMPOWERING HIGHER EDUCATION LECTURERS THROUGH TEMP: AN INNOVATIVE E-MENTORING MODEL

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Abstract

This qualitative study presents TEMP (Teaching E-Mentoring Process), an institutional e-mentoring framework implemented by a Teaching and Learning Center to support lecturers' pedagogical development in digitally evolving higher education environments. Approximately 300 lecturers participated in the TEMP program, and 75 completed a full open-ended qualitative questionnaire analyzed through thematic analysis. Findings reveal three central themes: development of technical pedagogical competence, implementation of active teaching strategies, and improved course structure. The results demonstrate both immediate pedagogical change and a transfer effect across teaching contexts. TEMP is presented as a scalable, reflective, and sustainable faculty development framework.

Keywords: *E-mentoring, faculty development, reflective practice, higher education, teaching innovation.*

1. Introduction

Higher education institutions are undergoing accelerated pedagogical transformation driven by digitalization, the rapid development of generative artificial intelligence, and changing student expectations. Lecturers are increasingly expected to implement active, technology-enhanced, and student-centered pedagogies, often without structured and continuous professional support.

Traditional faculty development initiatives are typically based on short-term workshops that provide general pedagogical guidelines. However, such models rarely result in sustainable pedagogical change. Contemporary research emphasizes the need for continuous, reflective, and context-based professional learning frameworks that are embedded within lecturers' authentic teaching environments.

In this context, e-mentoring has emerged as a promising approach for offering personalized, flexible, and scalable professional development (Tinoco-Giraldo et al., 2022). This study introduces TEMP (Teaching E-Mentoring Process), an institutional e-mentoring model designed to foster pedagogical excellence, reflective practice, and sustainable innovation in higher education.

2. The TEMP model

TEMP is a structured seven-stage e-mentoring model implemented throughout the academic semester as part of the institutional Teaching and Learning Center faculty development program.

The seven stages include mapping lecturers' pedagogical needs, mentor matching, lesson selection, digital observation, individual or group mentoring sessions, developmental planning, and reflective feedback. The model emphasizes confidentiality, flexibility, and alignment with individual teaching goals.

3. Methodology

A qualitative research design was selected in order to capture lecturers' lived experiences of the TEMP process. Approximately 300 lecturers participated in the TEMP program across multiple academic disciplines. Of these, 75 lecturers completed a full open-ended qualitative questionnaire and constituted the research sample.

Data were collected through open-ended questionnaires focusing on perceived pedagogical changes, mentoring experiences, and professional development outcomes. Data were analyzed using thematic analysis to identify recurring patterns and themes. Ethical standards of voluntary participation and anonymity were maintained.

4. Findings

Three central themes emerged from the qualitative analysis. First, lecturers reported significant improvement in technical pedagogical competence, including increased confidence in digital tool integration and lesson design.

Second, participants described greater use of active teaching strategies, such as collaborative learning, interactive questioning, and student-centered classroom activities.

Third, lecturers highlighted improved course structure, coherence, and alignment between objectives, teaching activities, and assessment.

5. Discussion

The findings of this study suggest that TEMP functions as more than a supportive mentoring initiative; it operates as a structured developmental process that enables meaningful pedagogical change. Participants described not only immediate improvements in teaching practice, but also a growing capacity to reflect on their pedagogical decisions and transfer insights to additional courses and contexts.

These findings align with research emphasizing reflective practice and situated professional learning as key mechanisms for long-term pedagogical development. By grounding mentoring in authentic teaching situations through digital observation and dialogue, TEMP enables lecturers to examine their practice in context and to experiment with change in a supported, low-risk environment.

An important contribution of TEMP lies in its adaptive design. Rather than relying on a fixed mentoring script, the process allows mentoring goals, formats, and focal points to evolve in response to changing pedagogical demands, technological developments, and institutional realities.

At the system level, the model offers important implications for how institutions conceptualize faculty development. As Abdollahi and Heshmati Nabavi (2023) demonstrated, structured mentoring programs significantly advance faculty members across multiple professional dimensions. TEMP creates inclusive pathways for professional learning, particularly for lecturers who may have previously felt marginalized or disengaged from formal development initiatives.

6. Conclusion

TEMP represents a reflective, flexible, and scalable e-mentoring framework that promotes pedagogical innovation, professional identity development, and teaching excellence in higher education.

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FROM STORY TO STEM: EMPOWERING STUDENTS THROUGH DIGITAL STORYTELLING IN GENDER EQUALITY EDUCATION

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Abstract

This paper presents findings from the piloting phase of the *Digital Stories* set developed within the Erasmus+ project *Digital Bridges Over the Gender Gap* (2024–2026), an international initiative promoting gender equality and inclusion in school education through innovative digital pedagogies. The project's central objective is to bridge gender disparities in career aspirations—especially in STEM fields—by integrating digital storytelling into teaching practice. Digital storytelling was introduced in four European partner schools as both a creative learning method and a tool for social reflection. The *Digital Stories* set features narratives of women who have achieved success in traditionally male-dominated fields such as science, technology, and engineering. The piloting involved teachers and students aged 13–18, who participated in classroom-based and online activities combining digital story creation, viewing, and discussion. To assess the educational and motivational impact, data were collected through semi-structured interviews with teachers and focus group interviews with students. The results indicate that digital storytelling significantly enhanced students' engagement, empathy, and reflection on gender stereotypes. Teachers described the method as an innovative and flexible pedagogical approach that encourages creativity, collaboration, and digital competence development. Students found the stories emotionally compelling and relatable, reporting that they could "see themselves" in the protagonists' experiences. Many expressed a renewed interest in exploring STEM-related studies and careers, attributing their motivation to the immersive and authentic nature of the digital stories. The process of co-creating and interpreting stories also strengthened learners' narrative, media, and communication skills. These findings suggest that digital storytelling can serve as a transformative educational strategy that connects narrative meaning-making with social change. It enables teachers to foster inclusive learning environments and supports students in developing both digital literacy and self-efficacy. The *Digital Bridges* project demonstrates how transnational collaboration can generate sustainable pedagogical innovations addressing gender equality, inclusion, and digital transformation in education.

Keywords: *Digital storytelling, gender equality, STEM motivation, inclusive education, Erasmus+.*

1. Introduction

Persistent gender disparities in students' educational choices and career aspirations in science, technology, engineering, and mathematics (STEM) remain a well-documented challenge across Europe. Despite sustained policy efforts at the European and national levels, girls and young women continue to be underrepresented in many STEM pathways, particularly in technology and engineering fields (European Commission, 2023; OECD, 2023). Research consistently shows that these disparities emerge early in adolescence and are strongly shaped by gender stereotypes, social expectations, and students' developing academic identities rather than by differences in ability (Eccles & Wang, 2016; UNESCO, 2024).

Traditional educational interventions aimed at reducing the gender gap in STEM have often relied on informational approaches or exposure to role models, such as presenting biographies of successful women scientists or organizing career talks. While such initiatives may temporarily raise awareness, evidence suggests that their impact on students' long-term motivation and self-concept is limited when not accompanied by deeper reflective and identity-oriented learning processes (Cheryan et al., 2017; Master et al., 2021). Students may recognize the achievements of female role models without perceiving these trajectories as personally attainable or relevant to their own lives.

Syntheses of empirical studies indicate that digital storytelling supports learning outcomes across cognitive, affective, and social domains, including academic achievement, engagement, communication skills, and reflective capacity (Moreau et al., 2018; Nasir et al., 2024). Crucially, the strongest and most sustained effects are observed when learners actively create or co-create digital stories rather than passively

consume them, when reflection is explicitly scaffolded through prompts or frameworks, and when implementation extends over sufficient time to allow for iterative development.

Despite the expanding literature on digital storytelling in education, important gaps remain. First, there is limited empirical research that explicitly examines digital storytelling as a pedagogical strategy for gender equality education within school-level STEM contexts. Much of the existing work focuses on higher education, teacher education, or language learning, leaving secondary education underrepresented. Second, relatively few studies adopt a dual-perspective approach that captures both student and teacher experiences, particularly within transnational educational initiatives where contextual diversity and transferability are critical considerations.

The aim of this study is to explore how digital storytelling supports student engagement, reflection on gender stereotypes, and motivation towards STEM pathways within upper primary and secondary education. The study addresses the following research questions:

1. How do students perceive digital stories portraying women in STEM careers?
2. How does digital storytelling influence students' reflection on gender stereotypes?
3. How do teachers evaluate digital storytelling as a pedagogical tool for gender equality education?

2. Methods

This study adopted a qualitative, exploratory, multi-site case study design to investigate digital storytelling as a pedagogical intervention in authentic educational contexts. The research was embedded within the Erasmus+ project *Digital Bridges Over the Gender Gap* (2024–2026), which promotes gender equality and inclusion in school education through innovative digital pedagogies. A case study approach enabled the exploration of how digital storytelling was experienced and interpreted by students and teachers across different national and institutional settings (Yin, 2018).

The study was conducted in four schools in different European countries. Participants included students aged 13–18 from upper primary, lower and upper secondary levels and teachers from STEM-related and transversal subjects. The intervention focused on a Digital Stories set portraying women in traditionally male-dominated STEM fields, highlighting authentic career trajectories, challenges, and turning points. Data were collected through semi-structured interviews with teachers and focus group interviews with students to capture in-depth perspectives on engagement, reflection, and perceived impact. Ethical standards for educational research were observed, including informed consent, voluntary participation, anonymity, and secure data handling.

Data analysis followed a reflexive thematic analysis approach (Braun & Clarke, 2021), combining deductive and inductive coding. Initial codes focused on engagement, empathy, reflection, and STEM-related self-efficacy, with inductive coding used to identify emergent themes.

3. Results

The qualitative analysis yielded four interrelated themes addressing students' and teachers' experiences of digital storytelling in the context of gender equality and STEM education. Students across all participating schools perceived the digital stories as *relatable*, *authentic*, and emotionally engaging. The narrative format and multimodal elements enabled students to connect more strongly with the protagonists, often describing the women portrayed in STEM as "people like us" rather than distant role models.

Focus group data revealed clear evidence of dialogic reflection. Students compared their prior assumptions about gender and STEM with the perspectives presented in the stories, frequently questioning stereotypical associations between masculinity and technical competence. In several cases, reflections developed towards emerging critical reflection, particularly when students discussed structural influences such as social expectations or limited encouragement for girls in STEM. Such depth of reflection was most evident when discussions were supported by guided prompts and peer dialogue, echoing earlier findings on the role of digital storytelling in fostering critical engagement with gender norms (Moreau et al., 2018).

From the teachers' perspective, digital storytelling was evaluated as a pedagogically valuable and flexible approach for addressing gender equality in STEM education. At the same time, teachers identified challenges related to limited instructional time and lack of technical support - common implementation constraints reported in digital storytelling research (Moreau et al., 2018; Nasir et al., 2024).

4. Discussion

The findings confirm that digital storytelling can support affective engagement and reflective learning in upper primary and secondary education. Students' emotional resonance with the narratives and

shifts in perceptions of gender and STEM careers align with prior research highlighting the importance of narrative relevance and personal identification in digital storytelling-based learning (Kendrick et al., 2022).

The results also reinforce the distinction between active meaning-making and passive exposure identified in the literature. Although students responded positively to viewing digital stories, deeper reflection—especially dialogic and emerging critical reflection—occurred primarily when viewing was embedded within guided discussion and reflective prompts. This supports evidence from reviews indicating that digital storytelling yields stronger learning and reflective outcomes when learners actively interpret and discuss narratives rather than merely consume them (Moreau et al., 2018; Nasir et al., 2024).

Several limitations should be noted. The qualitative, exploratory, and pilot-scale nature of the study limits generalisability, and reliance on self-reported perceptions may reflect short-term effects. Moreover, the absence of longitudinal data prevents conclusions about sustained impact on students' STEM choices. Future research should therefore employ mixed-methods and longitudinal designs and explore stronger integration of story creation alongside viewing, as co-creation and iterative storytelling have been shown to foster deeper reflection and learner ownership (Nasir et al., 2024).

5. Conclusions

This study demonstrates that digital storytelling can function as a meaningful and effective pedagogical approach for promoting student engagement, reflective thinking, and motivation towards STEM pathways. By presenting socially relevant narratives of women in STEM and embedding them in guided, dialogic learning activities, digital storytelling enabled students to critically examine gender stereotypes and to envision more inclusive possible futures for themselves.

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CAN THE DIFFERENT FORMS OF PREJUDICE BLATANT OR SUBTLE, AVERSIVE, REIFICATION, ETC BE APPLIED IN SAUDI ARABIA? ARE THERE ANY OTHER WAYS IN WHICH PREJUDICE IS EXPRESSED, SHOWN IN SAUDI ARABIA

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Abstract

This study examines different forms of prejudice, including blatant, subtle, and aversive racism, and explores how they may be expressed within the Saudi Arabian context. Drawing on social psychological theories, the research analyses how prejudice can appear both explicitly and implicitly across social and institutional settings. The study highlights discrimination toward immigrants, gender-based inequality, and social biases related to cultural and group differences. Findings suggest that while legal and religious frameworks emphasize equality, certain forms of indirect discrimination may still exist in practice. The study contributes to understanding how modern forms of prejudice operate in non-Western societies.

Keywords: *Discrimination, aversive racism, Saudi Arabia, immigrants.*

1. Introduction

Prejudice continues to exist in modern societies despite social norms opposing discrimination. Recent research has shifted focus toward subtle and indirect forms of prejudice, such as modern racism, aversive racism, and symbolic racism (Akrami, Ekehammar, & Araya, 2000; Benokraitis & Feagin, 1986; Gaertner & Dovidio, 1986; Sears, 1988)

These forms are often less visible but can significantly influence attitudes and behaviours toward minority groups.

Researchers such as Pettigrew and Meertens (1995) distinguished between blatant and subtle prejudice. Blatant prejudice is direct and openly expressed, while subtle prejudice is indirect and often difficult to detect. It may involve resentment toward cultural differences, defence of traditional values, and denial of positive intentions toward minority groups.

2. Theoretical background

Prejudice can be categorized into cognitive, affective, and conative forms (Farley, 2000). Cognitive prejudice refers to beliefs about a group, affective prejudice relates to emotional reactions, and conative prejudice involves behavioural tendencies.

Social psychologists have attempted to explain prejudice through several theories. Asch (1951) demonstrated conformity to group opinions, while Milgram (1974) highlighted obedience to authority. Other approaches link prejudice to personality differences or competition over limited resources. Social Identity Theory explains how group identification can lead to in-group favouritism and bias against others (Tajfel & Turner, 1979).

3. Forms of racism

Over time, racism has evolved from overt and easily identifiable forms to more subtle and implicit expressions (Dovidio, Kawakami, Smoak, & Gaertner, 2008). Blatant racism involves direct discrimination, while subtle racism operates unconsciously through avoidance or exclusion (Sue, 2005). Because it is harder to recognize, subtle racism may have stronger psychological effects, including negative impacts on self-esteem (Crocker & Major, 1989; Major, Kaiser, & McCoy, 2003; Major, Quinton, & Schmader, 2003).

Aversive racism represents a modern form of prejudice in which individuals hold conflicting attitudes, supporting equality while acting in discriminatory ways justified by non-racial reasons (Gaertner & Dovidio, 1986).

4. Prejudice in Saudi Arabia

One of the severe problems in society today is discrimination. It is not only the West that suffers from it; Saudi Arabia also faces many kinds of discrimination. Islam eliminates discrimination, but in Saudi Arabia, racism is widespread and often targets non-Arabs and sometimes Saudis themselves.

Being a non-Arab in Saudi Arabia is not easy, as people often look down on them. Non-Arabs face limited rights, including restricted access to public hospitals and universities, leaving them to rely on costly private services. Children of non-Arab men can only gain Saudi nationality at eighteen, and this applies only to sons.

Workers from third-world countries, like Bangladesh and Pakistan, often work long hours and face harsh treatment, insults, and even abuse. Westerners are seen as intelligent and upper-class but immoral. Non-Saudi Arabs are often considered thieves and treated badly.

Discrimination also exists among Muslims; Saudis often see other Muslims as following the "wrong" Islam. There is racism among Saudis themselves, especially against Black people. The Shia sect faces discrimination, sometimes being viewed as non-Saudi or non-Muslim.

Most Saudis belong to tribes; those outside are considered non-Saudi and face barriers in marriage, work, and government positions. High-ranking roles are often reserved for Bedouins and tribal Saudis (Verri, G., 2013).

5. Challenges faced by policemen when dealing with immigrants

In Saudi Arabia, prejudice may appear in various social and institutional contexts. Immigrants, particularly from developing countries, may face unequal treatment in employment and access to services. Cultural differences, language barriers, and social perceptions contribute to these challenges.

Gender-based discrimination is another important dimension. Women may face limitations due to guardianship requirements in areas such as education, travel, and employment. Inequality is also reflected in nationality laws, where women cannot transfer citizenship in the same way as men.

Additionally, certain social groups may experience bias based on cultural, religious, or tribal differences. These patterns may reflect subtle or aversive forms of prejudice rather than direct discrimination.

6. Social psychological theories of prejudice

The end of World War II leads humanity to question: How could it have been possible? Social psychologists tried to understand how the holocaust could have occurred. The view of Solomon Asch (1951) was that, even when the truth is apparent, people may deny declaring it in the presence of a group of people who, together, see it as untrue. Another researcher Stanley Milgram (1974) showed that a society that has a hierarchical system will find its people considering themselves as having the right to authority and coincidently carry out extreme actions. These people go against what they believe in when they are ordered to do so, as well as, when they are freed of the responsibility of their actions.

The first approach of prejudice, regarding the type of personality people have, focuses on why some people are more prejudiced than others, in other words, individual differences. These types of approaches to prejudice have been disapproved of because of the assumption that prejudice is related to personality of character that should, supposedly, be balanced.

The second approach to prejudice assumes that competing over a lack of resources leads to chauvinism and favoritism of groups.

The third approach puts forth an emotionally motivated explanation and originates from the work of Henri Tajfel and his colleagues (Tajfel & Turner, 1979). To begin with their studies were done on experimental groups and pointed to the fact that the existence of emotion of two groups *is* sufficient to cause feelings of chauvinism and favoritism of the majority group.

7. Women discrimination in Saudi Arabia

Among Arab countries, Saudi Arabia is where women may face the most prejudice and humiliation. Women encounter discrimination in marriage, child custody, and divorce. They cannot make major life decisions without a male guardian—husband, father, or even son—who must approve marriage, travel, work, or education.

Women cannot make decisions regarding their children, such as school enrolment or opening bank accounts, without the father's permission. Many fields of study, like politics, architecture, or engineering, are forbidden for women; teaching is one of the few acceptable careers.

Women cannot pass their nationality to their children or husbands if married to a non-Saudi, while men can pass nationality freely, showing clear gender discrimination. Saudi women were allowed identity cards in 2002 but still require guardian approval. Previously, single, divorced, or widowed women needed male support to access state benefits.

The Saudi government must review policies to ensure gender equality and end discrimination, similar to Western countries.

8. Conclusion

In conclusion, although different forms of prejudice can be identified in social and institutional contexts, the legal framework in Saudi Arabia is based on Islamic Sharia principles that emphasize justice and non-discrimination. Individuals should not be treated differently based on nationality, culture, or background. However, addressing both explicit and implicit forms of prejudice remains essential to ensuring fairness, equality, and cultural understanding in practice.

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AN INTERDISCIPLINARY DOCTORAL PROGRAM FOR CREATIVE AND SUSTAINABLE INNOVATION

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Abstract

The doctoral program in Creativity, Social and Sustainable Innovation at the CREA Campus of the University of Vigo represents an innovative and transformative model of doctoral education designed to promote interdisciplinary and transdisciplinary between all the areas of knowledge taught on this campus. Conceived within the framework of contemporary higher education reform, the program responds to the growing demand for flexible, integrative, and socially engaged doctoral training capable of addressing complex global challenges. At its core, the program emphasizes the importance of aligning doctoral projects with two distinct research lines from different fields or disciplines. The program operates as a dynamic learning ecosystem and a hub for academic collaboration, supported by the School of Forestry Engineering and several faculties on the Pontevedra campus, including Fine Arts; Education and Sports Sciences; Physiotherapy; Social Sciences, Communication and Design; and Direction and Public Management. This interdisciplinary academic promotes collaborative learning, cross-faculty teaching practices, and the co-creation of knowledge among doctoral students and faculty members from diverse educational and professional backgrounds. At least two experts who bring their specialized knowledge to enrich the doctoral work guide these projects. This structure encourages collaboration across traditionally separate domains, enabling innovative approaches to complex societal challenges. Furthermore, students benefit from a dynamic academic environment that integrates diverse methodologies and perspectives, enhancing both the depth and impact of their research.

Keywords: *Interdisciplinary doctoral education, transdisciplinary, innovative research training, creativity and social innovation, higher education pedagogy.*

1. Introduction

Creativity and innovation are essential forces behind economic expansion, sustainable progress, and the transformation of ideas into real value. They are crucial across all sectors, acting as key drivers of advancement and long-term success. While creativity involves the generation of original ideas, innovation focuses on putting those ideas into practice, resulting in new products, services, or processes. Together, they create a dynamic synergy that strengthens organizations and societies, enhancing competitiveness and supporting continuous development.

In the framework of the European Union (EU), these two elements occupy a central place in policy-making, with the European Commission highlighting their role as fundamental engines of growth. Innovation, in particular, is vital for reinforcing the EU's position in the global landscape and for addressing emerging and future challenges effectively. For this reason, research and innovation have consistently been prioritized within the EU's strategic agenda, with ongoing efforts to promote them as key contributors not only to economic performance but also to social welfare and overall prosperity.

The relevance of encouraging creativity and innovation in Europe is widely recognized. Decision No. 1350/2008/EC of the European Parliament and of the Council (16 December 2008) points out the urgent need to strengthen Europe's creative and innovative capacity for both economic and social purposes. Likewise, the European Council has emphasized that innovation is critical for responding to the demands of globalization. Achieving this requires equipping citizens with creative competencies that enable them to

view change as an opportunity and to engage with new ideas. These abilities are also fundamental for fostering active involvement in an increasingly diverse, knowledge-driven society.

In academic research, knowledge has traditionally been organized into separate disciplines, fostering a high degree of specialization that, while valuable, often limits the understanding of complex issues requiring broader perspectives. This contrasts with earlier conceptions of knowledge, such as in classical Greek thought, where technique (techne), creation (poiesis), theory (theoria), and practice (praxis) were viewed as interconnected dimensions of a unified system (Alsina, 2007; Gonzalez et col., 2011; Villar, 2011). In contemporary academia, however, this holistic vision has largely been replaced by fragmented approaches that isolate fields of study. As noted by Tornero (2016), the strong emphasis on maintaining disciplinary boundaries has led to an excessive rigidity, restricting the development of more comprehensive and integrative views of the world.

Interdisciplinarity promotes deep integration of knowledge across disciplines, emphasizing that combined insights create a more comprehensive understanding than separate contributions alone (Cabal, 2008). Transdisciplinarity is an approach that goes beyond single disciplines by combining academic and non-academic knowledge to co-create solutions for complex societal challenges, emphasizing collaboration, shared learning, and context-specific frameworks (Lang et col., 2012).

An illustrative example of this interdisciplinary approach is the CREA Doctoral Program at the University of Vigo in Galicia, Spain. Based at the Pontevedra campus, this program adopts a hybrid working methodology aimed at promoting creativity and innovation through collaboration across different fields. The CREA Doctoral Program in Creativity and Sustainable Social Innovation is specifically designed to support interdisciplinary research and doctoral training, enabling students to integrate diverse areas of knowledge.

This approach equips doctoral candidates with the tools needed to address complex social and environmental challenges by developing creative and practical solutions. Grounded in the idea that today's global issues require both technical expertise and cross-disciplinary thinking, the program places strong emphasis on sustainability and social innovation. As a result, it prepares students to contribute meaningfully to societal progress, encouraging the development of innovative responses to challenges such as climate change, social inequality, and economic development.

2. Content and development of the doctoral program

The CREA PhD program is delivered at the University of Vigo, on the Pontevedra campus (Spain), and is designed to promote inter- and transdisciplinary collaboration across all areas of knowledge taught there. The doctoral program in Creativity, Social and Sustainable Innovation, based at the CREA Campus, stands out for its strong commitment to advancing academic interdisciplinarity. Its primary aim is to explore the key drivers of development through creativity and innovation, fostering a transversal approach supported by multidisciplinary research teams.

The program operates as a dynamic learning ecosystem and a hub for academic collaboration, supported by the School of Forestry Engineering and several faculties on the Pontevedra campus, including Fine Arts; Education and Sports Sciences; Physiotherapy; Social Sciences, Communication and Design; and Direction and Public Management. This interdisciplinary academic environment promotes collaborative learning, cross-faculty teaching practices, and the co-creation of knowledge among doctoral students and faculty members from diverse educational and professional backgrounds.

These doctoral studies were officially published in the DOG on 14/07/2017 and in the BOE on 24/10/2017, with teaching commencing in the 2017/2018 academic year. The program initially established a maximum intake of 20 students; however, over the past two years, this limit has been exceeded due to growing demand, with 24 students enrolled. On average, around 30% of enrolled students come from other universities.

The program requires that each doctoral project be aligned with at least two main thematic lines, selected from areas such as health innovation; innovation, sustainability and communication; social design and innovation; innovation and sustainability of natural resources; governance and innovation; and pedagogical innovation in teacher professionalization. Accordingly, each project must be supervised by two directors from different fields of knowledge, ensuring a genuinely interdisciplinary approach.

These thematic lines remain flexible and are adapted to the specific needs of each project, promoting both academic and research innovation. They bring together specialists from diverse disciplines who collaborate in the co-supervision process, guiding doctoral candidates to integrate multiple perspectives around a shared topic. By encouraging interdisciplinary dialogue and focusing on themes rather than isolated disciplines, the program enables a deeper and more comprehensive exploration of current educational, environmental, and cultural challenges.

Final admission to the doctoral program includes the assignment of a tutor or director linked to one of the research lines. In collaboration with the doctoral candidate, this supervisor is responsible for identifying a second director from a different research line, who may belong either to the university or to an external institution. The doctoral student is required to complete 100 hours of compulsory general training activities and may also participate in additional optional seminars. The mandatory activities are: Seminar to present research lines; Defense of the research plan; Public communication seminar; Written communication seminar in English; Research Seminar: search, ethical use, dissemination and publication of scientific information; Researchers Seminar: academic career, research projects and scientific publication and Research Methodology Seminar. The optional activities are: Qualitative Research Methodology Seminar; Normative databases and politicalological approach Seminar and The comparative method in the preparation of documentation theses Seminar. In order to improve student training, three new optional training activities have been proposed for the next academic year 2026/2027.

Since the pandemic, training activities have been offered in a hybrid format, either online or in person, depending on the student's preference. Each year, the program's academic committee evaluates the student's research plan, activity record, and accompanying reports. This report must be prepared annually by the program director.

A positive evaluation is a mandatory requirement for continuing in the program. If the evaluation is negative, it must be clearly justified, and the doctoral student must undergo a re-evaluation within six months. To do so, a new Research Plan must be developed. If the second evaluation is also negative, the student will be permanently withdrawn from the program.

In addition to these training activities, students are required to participate in at least two national or international scientific conferences during their training period, presenting a scientific contribution in the form of a paper or poster.

The estimated duration from the start of the program to the thesis defense is three years for full-time students and five years for part-time students, with the possibility of one extension.

Since the program's inception in 2017, 24 doctoral theses have been successfully defended, demonstrating that interdisciplinary research is achievable across diverse fields. These include combinations that may initially seem distant, such as textile design and forestry; health and education; communication and sports; education and communication; governance and education; and art and chemical engineering, among others.

3. Conclusion

In summary, creativity and innovation play a fundamental role in advancing society, as they provide effective responses to many of today's most urgent challenges. Through the promotion of creative thinking and the support of interdisciplinary approaches, the European Union and institutions such as the University of Vigo contribute to building a more sustainable and forward-looking future. Within this context, the CREA campus and its interdisciplinary doctoral program serve as a platform for methodological innovation, enabling the in-depth exploration of complex issues that require comprehensive and integrative perspectives.

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GAMIFICATION AND VISUAL MODELS AS TOOLS TO SUPPORT UNDERSTANDING OF ATOMIC STRUCTURE AMONG SECONDARY SCHOOLS STUDENTS

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Abstract

Atomic structure is one of the most abstract and challenging topics in chemistry education. Students often struggle to visualize submicroscopic structures and to grasp atomic models and the concept of orbitals. Traditional lecture-based methods frequently prove insufficient, leading to decreased motivation and the reinforcement of misconceptions. The aim of this project was to develop and evaluate the effectiveness of alternative teaching methods for atomic structure, based on gamification and analogical models. It is assumed that incorporating elements of play and narrative (e.g., the periodic table as a game board, orbitals as airplane flight paths) enhances students' understanding, engagement, and long-term retention of knowledge. The study involved a group of secondary school students divided into an experimental group (taught using games and analogies) and a control group (taught using traditional methods). The effectiveness of the methods was assessed through a knowledge test, a questionnaire on perceived difficulty, and observation of student activity during lessons. Additionally, interviews with students and teachers were conducted to evaluate the attractiveness and educational potential of the developed models. The findings indicate that the use of gamification and analogical thinking significantly improved students' comprehension of abstract concepts and increased their motivation to learn chemistry. The results may serve as a basis for developing a set of innovative teaching tools and lesson plans that foster scientific competencies through play, experience, and imagination.

Keywords: *Gamification, analogical models, analogical thinking, alternative teaching methods in chemistry.*

1. Introduction

The teaching of chemistry belongs to areas of science education in which students often encounter difficulties due to the high level of abstraction of presented concepts. One of the most demanding topics is atomic structure, as it requires operating at the submicroscopic level and integrating multiple representations of knowledge, such as graphical models, symbolic notation, and mathematical interpretations (Johnstone, 1991). Students must develop the ability to imagine invisible structures and understand theoretical models, which often leads to alternative conceptions and misconceptions (Taber, 2013).

The literature indicates that difficulties in learning chemistry arise not only from the nature of the content but also from the dominance of traditional lecture-based teaching methods. Transmission-oriented approaches limit students' opportunities to actively construct knowledge and develop deep conceptual understanding (Gilbert & Treagust, 2009). In response, constructivist-based strategies increasingly emphasize the active role of the learner.

One such approach involves the use of cognitive analogies, which help students map familiar experiences onto new scientific concepts, reducing cognitive load and supporting mental representation building (Orgill & Bodner, 2004). Gamification is also gaining importance as a strategy supporting intrinsic motivation and engagement through narrative, challenges, and immediate feedback (Hamari, Koivisto, & Sarsa, 2014; Kalogiannakis, Papadakis, & Zourmpakis, 2021).

Despite growing research on analogies and gamification, their integration as a coherent instructional environment influencing cognitive, emotional, and metacognitive processes remains underexplored. The present study aims to address this gap by analyzing the effects of an integrated instructional approach in teaching atomic structure.

2. Objectives

The main objective of the study was to evaluate the effectiveness of integrating instructional analogies and gamification elements in teaching atomic structure.

The specific objectives included: determining the impact of the applied methods on the level of conceptual understanding of chemical topics, analyzing students' emotional experiences during the learning process, assessing the development of metacognitive competencies, such as self-regulation of the learning process, investigating the potential for knowledge transfer and the ability to apply analogies in new contexts.

3. Methods

The study had a quasi-experimental design and involved 150 participants, mostly secondary school students (72.8%), with the remainder at the university level. The sample was predominantly female (73.9%) and mainly aged 15–19. The instructional approach was based on a constructivist learning model (Bransford, Brown, & Cocking, 2000). The experimental group participated in lessons integrating instructional analogies and gamification elements, including visual analogies linking atomic structure to familiar objects and narrative activities such as interpreting the periodic table as a game board. The aim was to support spatial imagination and promote active knowledge construction through familiar experiential schemas, while the control group followed traditional instructional methods.

Data collection used triangulation of methods, including Likert-scale quantitative surveys, qualitative analysis of open-ended responses, and observations of student activity during lessons.

4. Results

The analysis revealed significant differences between the experimental and control groups in both cognitive outcomes and emotional experiences. In the experimental group, most students reported improved understanding of atomic structure, easier memorization, and better visualization of submicroscopic concepts, indicating that analogies and gamification effectively reduced the abstract nature of the content.

In contrast, only about 30% of students in the control group reported understanding the material. Many experienced difficulties related to visualizing atomic structures and lacked effective learning strategies, often relying on rote memorization. Emotional analysis showed that around 80% of control group participants experienced high stress levels associated with cognitive challenges, leading to frustration and decreased motivation.

Positive educational emotions such as curiosity, engagement, and cognitive comfort predominated in the experimental group. Students emphasized that analogies helped them conceptualize invisible processes, while gamification promoted active participation and reduced fear of making mistakes. More than half of the experimental group also reported improved metacognitive skills, including self-regulation and the development of individual learning strategies.

5. Discussion

The findings indicate that integrating instructional analogies with gamification produced multidimensional effects across cognitive, emotional, and metacognitive domains. Analogies supported the construction of mental representations of submicroscopic structures, facilitating a shift from rote learning to deeper conceptual understanding. Gamification enhanced engagement, reduced stress, and created a psychologically safe environment that encouraged experimentation and problem-solving.

Students also demonstrated increased metacognitive awareness and benefited from social learning through collaboration and discussion. A conceptual model emerges in which analogies reduce cognitive abstraction, while gamification strengthens emotional engagement and psychological safety, together supporting deeper processing and improved knowledge transfer.

The contrast between groups highlights the relationship between cognitive understanding and emotional experience. Control group students often experienced stress linked to difficulties in visualizing abstract concepts, which led to reliance on memorization and decreased motivation. These findings align with previous research suggesting that analogies function as cognitive bridges and that gamification enhances engagement and learner agency.

6. Conclusions

The study suggests that integrating analogical models and gamification can effectively support the teaching of highly abstract topics such as atomic structure. The approach simultaneously influenced cognitive, emotional, and metacognitive dimensions, improving understanding and increasing learner autonomy.

Analogies facilitated mental representation and conceptual understanding, while gamification enhanced engagement and participation. Clear differences between experimental and control groups highlight the importance of instructional design that addresses both cognitive and emotional aspects of learning. Such approaches may transform traditional teaching into environments that foster scientific thinking, creativity, and metacognitive development.

However, the approach may increase cognitive intensity, indicating the need to adjust pacing and instructional design. Future research should examine long-term effects on knowledge retention and transfer skills.

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ELECTRONIC TESTING AS A MOTIVATIONAL TOOL IN PRE-SERVICE TEACHER EDUCATION: A PILOT STUDY

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Abstract

Electronic testing has become an increasingly common component of higher education; however, its influence on the motivation and study strategies of pre-service teachers remains insufficiently explored. Attention should be paid to how students perceive e-tests during their preparation for credit assessments and whether this form of assessment supports learning processes, self-assessment, and regular study habits. This paper presents a pilot research study based on a questionnaire survey conducted among pre-service mathematics teachers in the Czech Republic and Slovakia. The study examines how students engage with electronic tests throughout the semester, to what extent they perceive them as a motivating factor, and which specific aspects of e-testing facilitate or hinder their study preparation. A comparative perspective is included to capture potential differences between the Czech and Slovak educational contexts. Initial pilot findings indicate recurring patterns in students' perceptions of electronic testing, particularly regarding the role of immediate feedback and opportunities for repeated practice. These factors appear to contribute to continuous study engagement and support learning-oriented use of assessment tools. The pilot study identifies key variables influencing the acceptance of electronic testing among future teachers and establishes a foundation for a broader follow-up investigation. The findings contribute to discussions on the effective integration of electronic testing into university teacher education and provide recommendations for the innovation of current assessment practices.

Keywords: *Electronic testing, student motivation, pre-service teachers, formative assessment, digital learning tools.*

1. Introduction

Electronic testing has become an integral part of contemporary education, particularly in higher education environments where digital tools are increasingly used to support both teaching and assessment. While electronic tests are often associated with summative evaluation, their potential as a tool for supporting learning processes, motivation, and self-regulation is gaining attention. However, the perception of e-testing among pre-service teachers remains relatively underexplored.

Future teachers play a key role in shaping educational practices, and their attitudes toward digital assessment tools may significantly influence their future classroom implementation. Understanding how pre-service teachers perceive electronic testing, especially in relation to motivation and study strategies, is therefore essential. This study focuses on identifying how electronic tests are used during the semester and whether students consider them beneficial for their learning.

2. Methods

The study was designed as pilot research based on a questionnaire survey. The participants were pre-service mathematics teachers studying at a university in the Czech Republic. The Slovak sample will be included in the subsequent phase of the research to enable a comparative analysis between the two educational contexts. Data were collected using a structured questionnaire focused on students' experiences with selected digital tools used for electronic testing, specifically Blooket and Wayground. The questionnaire included both closed-ended items using a Likert scale (1–5) and open-ended questions that allowed respondents to express their opinions on the advantages and disadvantages of these tools. The data were collected electronically, and participation in the survey was voluntary and anonymous. The research focused on several key areas: perceived usability of the applications, their impact on motivation and learning, and their potential use in future teaching practice. The data collection was conducted in November

2025 during the winter semester of the academic year 2025/2026. A total of 19 pre-service teachers participated in this pilot study.

3. Results

The results of the questionnaire indicate several recurring patterns in students' perceptions of electronic testing tools. The analysis combined both Likert-scale responses and open-ended answers, which provided deeper insight into students' experiences.

3.1. Usability and engagement

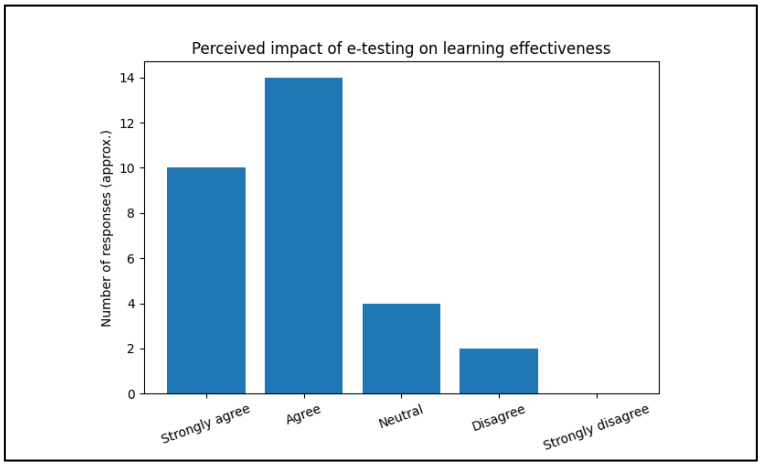
Most respondents evaluated both applications as intuitive and easy to use. Most students agreed that the applications were clear, well-structured, and user-friendly. At the same time, students frequently reported that working with these tools was enjoyable. The interactive and game-based nature of the applications, particularly in the case of Blooket, contributed significantly to increased engagement during learning activities.

3.2. Motivation and learning

The findings suggest that electronic testing tools have a positive impact on student motivation. Many respondents indicated that the use of these applications made them more willing to participate in learning activities and encouraged them to engage with the content more actively. Students also reported that repeated interaction with questions helped them better remember the subject matter. The motivational aspect was often linked to elements such as competition, immediate feedback, and the possibility of repeated attempts. These features appear to support continuous engagement and contribute to a more active learning process.

Figure 1 presents students' perceptions of the impact of electronic testing tools on learning effectiveness. Most respondents expressed a positive attitude, indicating that electronic testing supported their understanding and retention of the subject matter. Only a small number of students reported neutral or negative perceptions, which suggests that these tools are generally perceived a beneficial for learning processes.

Figure 1. Perceived impact of electronic testing on learning effectiveness (pilot data).

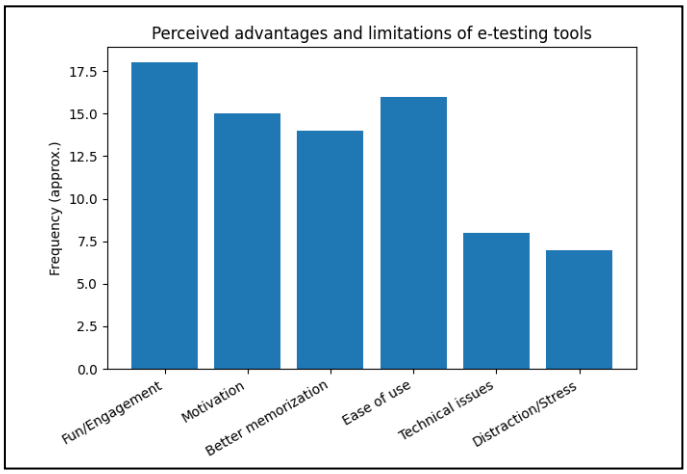


3.3. Advantages and limitations

The qualitative analysis of open-ended responses revealed several frequently mentioned advantages and limitations of the evaluated tools. Among the main advantages, students most often highlighted the entertaining and interactive nature of the applications. Many responses emphasized increased engagement, improved attention, and the opportunity to practice the material repeatedly. Ease of use and accessibility were also commonly mentioned as important benefits. On the other hand, several limitations were identified. Students pointed out technical issues, such as occasional application instability or insufficient access to digital devices in classrooms. Some respondents also noted that the competitive elements might lead to stress or distraction, especially in more dynamic classroom environments. Additionally, the preparation of high-quality question sets was perceived as demanding for teachers.

To provide an overview of these findings, Figure 2 presents the most frequently mentioned categories of advantages and limitations identified in the responses.

Figure 2. Perceived advantages and limitations of electronic testing tools (pilot data).



4. Discussion

The findings of this pilot study suggest that electronic testing tools can serve not only as assessment instruments but also as effective tools for supporting student motivation and learning. The positive perception of interactivity, immediate feedback, and repeated practice corresponds with current approaches emphasizing formative assessment and active learning. At the same time, the results indicate that the effectiveness of these tools depends on their appropriate implementation. While game-based elements can enhance engagement, they may also introduce distraction or stress in certain contexts. Technical limitations and unequal access to devices also remain important factors that can influence their successful use. The results presented in Figure 1 and Figure 2 highlight the dual nature of electronic testing: on the one hand, it increases motivation and supports learning, while on the other hand, it requires careful pedagogical and technological consideration.

5. Conclusions

This pilot study provides initial insights into how pre-service teachers perceive electronic testing tools in the context of their learning. The findings indicate that these tools are generally perceived as beneficial, particularly in terms of motivation, engagement, and support for repeated practice. However, their implementation should be approached thoughtfully, considering potential limitations such as technical issues and classroom management challenges. Future research, including the planned Slovak sample, will allow for a broader comparative analysis and contribute to a deeper understanding of the role of electronic testing in teacher education.

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DEVELOPING EMOTIONAL INTELLIGENCE TO FOSTER SUSTAINABLE CONSUMPTION: AN INTEGRATED APPROACH TO FUTURE EDUCATOR TRAINING

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Abstract

The growing complexity of sustainability challenges calls for higher education approaches that integrate cognitive, emotional, and ethical dimensions of learning. This Italian pilot case study investigates how an emotionally engaging, collaborative Design Thinking (DT) intervention can foster sustainability awareness and value-based orientations among undergraduate students. The intervention was implemented during the 2024/2025 Design Thinking course at LUMSA University (Rome). A mixed-method, quasi-experimental case study design was adopted. Qualitative data were collected through an in-class post-it activity, while quantitative analyses focused on matched pre–post questionnaires. Findings reveal multidimensional sustainability conceptualizations, ethically driven SDG engagement, and meaningful associations between pro-environmental behaviors, reduced psychological conflict, emotional variables, and well-being indicators, while short-term behavioral change remains limited.

Keywords: *Education for sustainable development, design thinking, emotional engagement, SDGs, higher education.*

1. Theoretical framing

Education for Sustainable Development (ESD) promotes pedagogies that are transformative, participatory, and action-oriented, fostering systems thinking, ethical awareness, and responsibility for collective well-being (UNESCO, 2020; Wals, 2020; Sterling, 2011; Bamber & Morgan, 2017). Within this framework, emotionally engaging learning environments are increasingly recognized as enabling conditions for reflective meaning-making and ethical agency (Mezirow, 1991; Ojala, 2023).

Design Thinking (DT), particularly when embedded in Project-Based Learning, offers a human-centered and collaborative approach that connects sustainability challenges to empathy, creativity, and applied problem-solving (Brown, 2009; Condliffe et al., 2017; Razzouk & Shute, 2020). Recent studies suggest that DT can support transformative sustainability learning by integrating reflection, collaboration, and real-world relevance (Leal Filho et al., 2018, 2022; Lehtonen et al., 2023). This study builds on these perspectives to explore how an emotionally engaging educational experience supports sustainability consumption choices and value-based orientations among undergraduate students.

2. Objectives and research question

This study examines an Italian pilot case implemented within a Design Thinking course at LUMSA University (Rome). The overarching research question is: **RQ:** How can a collaborative and emotionally engaging learning intervention foster sustainability awareness, personal reflection, and value-based action in higher education students? To address this question, the analysis focuses on four dimensions:

1. How students conceptualize sustainability;
2. Which SDGs they prioritize, and why;
3. What everyday sustainable behaviors they identify;
4. What preliminary quantitative patterns emerge across psychological barriers, emotional variables, and sustainability-related behaviors.

Prior to data analysis, it was expected that the intervention might elicit more multidimensional and value-laden sustainability conceptualizations and contribute to increased student awareness of the SDGs

and everyday sustainable consumption. It was also anticipated that short-term behavioral indicators would exhibit more limited change than awareness-related outcomes, and that reductions in psychological barriers could be associated with higher pro-environmental behaviors.

3. Methodology

A mixed-method, quasi-experimental case study with a transformative research perspective was adopted. The intervention took place during a Design Thinking course at LUMSA University (Rome). Participants included 150 undergraduate students ($N = 150$) involved in activities for qualitative analysis. Quantitative analyses focused on students who completed both pre- and post-questionnaires with matchable responses (N = 34).

For the Intervention and data collection two complementary learning activities were implemented. First, students completed an individual in-class reflection using color-coded post-it notes in response to three prompts ("Sustainability is…", "Preferred SDG and why", "Everyday actions to protect the planet"), generating over 280 qualitative responses. Second, students worked in collaborative teams (3–5 members) to co-design SDG-oriented interventions using the Design Thinking framework, presented orally at the end of the course. The learning environment was intentionally non-evaluative to promote psychological safety, creativity, and authentic engagement. Qualitative data were collected in November 2024. Quantitative pre- and post-intervention questionnaires were administered digitally around the intervention.

Qualitative data were analyzed using thematic analysis to identify categories related to sustainability conceptualizations, SDG preferences and motivations, and everyday actions. Quantitative analyses explored exploratory change patterns and correlations across sustainability-related variables, psychological barriers, emotional variables, and well-being indicators in the matched pre–post dataset (N = 34). All quantitative measures were derived from previously validated scales approved by the Ethics Committee of Sapienza University of Rome.

4. Results

4.1. Qualitative findings

Students' conceptualizations of sustainability revealed four core themes: intergenerational equity, environmental stewardship, social responsibility and equity, as well as sustainable lifestyles and innovation, indicating a multidimensional and value-laden understanding of sustainability. From over 100 valid contributions, SDG 5 (Gender Equality) was most frequently cited (~20%), followed by SDG 4 (Quality Education) and SDG 3 (Good Health and Well-being); SDG 8 also received several mentions. SDG 12 was rarely cited, while SDGs 9, 15, and 17 were not explicitly mentioned. Motivational rationales clustered into four macro-categories: ethical values (≈37%), intrinsic motivation (≈28%), systemic vision (≈19%), and personal experience (≈16%).

From 125 ideas, students identified everyday sustainable actions related to reducing waste and plastics (33), water conservation (21), sustainable consumption (18), energy saving (14), sustainable mobility (13), information and awareness (11), sustainable nutrition (9), and other creative ideas (6).

4.2. Quantitative findings (matched pre–post, N = 34)

Preliminary analyses revealed several relevant patterns. Improvements in pro-environmental behaviors were associated with a reduction in psychological conflict, as indicated by a negative correlation between pro-environmental behaviors and the *Conflicting* barrier ($r = -0.39$). Significant changes were also observed in the psychological barriers scale, with *Conflicting* decreasing and *Lacking knowledge* increasing in the post-test.

Changes in emotion appraisal were strongly correlated with perceived emotional intelligence and emotional competencies (r values ranging from 0.64 to 0.93). Additionally, changes in flourishing were positively associated with changes in happiness ($r \approx 0.60$). The four dimensions of the Pro-Environmental Behavior Scale (conservation, food, transportation, environmental citizenship) were positively interrelated, indicating coherent patterns across private- and public-sphere environmentalism.

5. Discussion and conclusion

This Italian pilot case study suggests that emotionally engaging learning environments can support students' sustainability awareness, ethical engagement with the SDGs, and everyday sustainable actions. Qualitative findings indicate a shift toward multidimensional, value-based understandings of sustainability, while preliminary quantitative patterns show that improvements in pro-environmental behaviors are

associated with reduced psychological conflict and linked to emotional and well-being variables. These results highlight the relevance of emotional processes in sustainability learning. At the same time, the persistence of the attitude–behavior gap is confirmed, as increased awareness does not automatically translate into immediate behavioral change (Colombo et al., 2023). As a single-case, convenience-based pilot with a limited matched sample, the findings are exploratory and not intended for statistical generalization. Overall, the study supports the integration of emotionally supportive educational practices to strengthen Education for Sustainable Development in higher education and foster more durable pro-environmental action.

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INTEGRATING AI TOOLS IN UX AND SOFTWARE EDUCATION: INSIGHTS FROM TEACHING PRACTICE

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Abstract

Artificial intelligence (AI) is increasingly influencing software engineering education. This paper reports experiences from integrating an AI-supported learning environment based on Google NotebookLM into a usability testing course in the master's program Software Engineering at the University of Applied Sciences Technikum Wien. Students used curated materials and structured question sets during self-study and applied usability and accessibility testing methods in practical exercises. Assessment was conducted through face-to-face examinations. Results show a high level of methodological correctness in the student work. Of 47 assessed students, 78.7% received the highest grade and the pass rate was 97.9%. Course evaluations were also very positive. The experience suggests that AI-supported learning environments can effectively support structured preparation and learning outcomes when combined with clear assignments and controlled assessment formats.

Keywords: *AI in software engineering education, usability testing, AI-supported learning.*

1. Introduction

Artificial intelligence (AI) is increasingly influencing software development and the way software engineering is taught in higher education. Tools based on large language models can support learning activities such as information retrieval, structured analysis, and the preparation of written material (Alanazi, et al., 2025; Shi et al., 2025; Manorat, Rattanapoka, & Srisuphab, 2025; Khan, Akbar, & Kasurinen, 2025). This development raises an important question for educators: how can AI tools be integrated into teaching while maintaining methodological rigor and reliable assessment?

This question is particularly relevant in courses that teach usability testing, where students must learn to design and interpret evaluations of interactive systems with users. These activities require the formulation of research questions, the preparation of structured test scenarios, and the analysis of observations—tasks that many students initially find difficult to structure.

The course "Usability Testing" in the master's program Software Engineering at the University of Applied Sciences Technikum Wien therefore integrates an AI-supported learning environment based on Google NotebookLM. Students interact with curated course materials and predefined guiding questions that structure their exploration of the content.

While AI tools support the learning phase, assessment is conducted through a face-to-face examination to ensure independent understanding of usability testing methods. This paper reports insights from this teaching approach and examines how AI-supported learning influences student engagement and comprehension in usability testing education.

2. Educational context

The course "Usability Testing" is part of the master's program Software Engineering (MSE) at the University of Applied Sciences Technikum Wien, Austria. The four-semester program combines advanced software engineering with human-centered design and interaction design competencies. Within this curriculum, usability and human factors are treated as essential elements of modern software development.

The course belongs to the Human Factors module and introduces students to the principles and methods of usability evaluation. Students learn how to plan, conduct, and analyze usability tests, including test scenarios, task design, observation techniques, and the interpretation of qualitative and quantitative findings.

Embedded in a technically oriented software engineering curriculum, the course connects usability evaluation with broader development practices. Students apply usability testing methods to digital systems and prototypes, learning how empirical user feedback informs design decisions and iterative development.

3. Teaching approach and examination method

The course "Usability Testing" follows a blended learning format combining structured self-study, practice-oriented classroom sessions, and competence-based assessment. The teaching design follows a flipped classroom approach in which students first acquire theoretical knowledge independently and then apply it in practical classroom activities.

A central element of the self-study phase is Google NotebookLM as an AI-supported learning environment. The environment is based on curated course sources, including the textbook User Experience and Usability: Basics and Methods (Seibert-Giller & Pucher, 2023), UX and accessibility training syllabi, and structured question sets used for exam preparation. Students work with approximately 100 guiding questions per session, supported by concise answer outlines, which help structure their preparation and deepen their understanding of usability and accessibility topics.

The learning materials also include precise task descriptions for both the usability test and the accessibility test conducted during the course. As a result, students enter the classroom sessions with a clear understanding of the methods and objectives of the exercises.

During the in-person sessions, students work in small groups to conduct usability tests on websites or applications. They take on different roles, such as moderator, participant, or observer, and systematically document usability issues. Additional activities address accessibility evaluation and the integration of usability findings into agile development processes such as Scrum.

Assessment combines practical work and individual knowledge verification. Students present the usability or accessibility tests they conducted and explain their methodological approach and findings. The theoretical questions are assessed exclusively in face-to-face examinations without AI support to ensure independent understanding. This approach ensures that students are able to apply usability and accessibility methods in a structured and professionally relevant way within modern software development environments.

4. Results

Students applied the methods studied during the AI-supported self-study phase in practical usability and accessibility evaluations. Working in small groups, they designed and conducted usability tests on selected websites or applications. Test tasks were defined, sessions were moderated using the think-aloud method, and usability issues were systematically documented. The results were summarized in short test reports and presented in class together with recommendations for interface improvements.

In addition, each group performed an accessibility evaluation of a website. Students applied WCAG-based criteria, used automated accessibility testing tools, and conducted manual checks such as keyboard navigation and screen reader testing. Identified accessibility barriers were documented and prioritized according to severity.

All students closely followed the clearly defined methodological guidelines and task descriptions provided in the course materials. As a result, the submitted reports and presentations showed a consistently structured approach and a high level of methodological correctness.

The grading results reflect this outcome. Of the 47 assessed students, 37 (78.7%) received the grade "Excellent", 9 (19.1%) received "Good", and one student (2.1%) received a failing grade. The average course grade was 1.43, with a median of 1 (Excellent) and an overall pass rate of 97.9%. These results indicate that the students were able to apply usability and accessibility evaluation methods successfully and according to the defined methodological framework.

5. Discussion

The results of the course are strikingly positive and require careful interpretation. With nearly eighty percent of the students receiving the highest grade and an overall pass rate close to one hundred percent, the outcomes may initially appear unusually strong. One possible explanation lies in the highly structured learning environment. The combination of curated learning materials, clearly defined tasks, and extensive guiding questions created a transparent framework that enabled students to prepare systematically for both the practical assignments and the face-to-face examination.

Another important factor is the AI-supported learning environment. The use of Google NotebookLM allowed students to interact with curated course sources and structured question sets in a

flexible way. Instead of replacing learning, the AI environment functioned as a scaffold that helped students organize information, clarify concepts, and rehearse explanations before the in-person sessions. This appears to be particularly effective in software engineering education, where students are accustomed to working with technical tools and structured problem-solving approaches.

The professional background of the students also plays a role. All participants in the master's program work at least part-time in industry. As a result, they are familiar with the practical challenges of software development and recognize the relevance of usability and accessibility testing in real projects. This professional experience likely contributed to the high level of engagement observed during the practical exercises and presentations.

Student feedback from the official course evaluation was also very positive. Overall satisfaction received an average rating of 1.00 on the Austrian five-point scale (1 = very positive). Students rated the course structure, clarity of explanations, and practical exercises with an average of 1.00. Learning objectives and examination modalities were rated 1.20, and alignment with other modules 1.40. The perceived workload was moderate (2.40). Qualitative feedback highlighted that the accessibility testing exercise helped students recognize the gap between regulatory requirements and the accessibility of many real-world websites.

At the same time, the strong results highlight an important methodological aspect: although AI tools supported the learning process, the assessment itself was conducted in a controlled face-to-face setting without AI assistance. This design ensured that the high grades reflect actual understanding rather than AI-generated answers.

Overall, the experience suggests that AI-supported learning environments can be particularly effective in software engineering education when combined with structured materials, clear assignments, and controlled assessment formats. Rather than replacing traditional teaching methods, AI tools can enhance preparation and comprehension while maintaining academic rigor.

6. Conclusion

The results of the course indicate that students were able to successfully apply usability and accessibility testing methods in a structured and methodologically sound manner. The combination of AI-supported self-study, clearly defined assignments, and practice-oriented classroom activities enabled students to prepare effectively for the practical exercises and examinations.

The grading results were very strong, with most students receiving the highest grade and an overall pass rate of 97.9%. Course evaluations were also highly positive, with students rating the structure of the course, the clarity of explanations, and the practical exercises very highly.

Overall, the results suggest that the combination of AI-supported learning environments, structured teaching materials, and face-to-face assessment can support effective learning outcomes in usability testing education within software engineering programs.

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RETHINKING ONLINE DOCTORAL EDUCATION: DIGITAL INNOVATION, E-LEARNING AND AI IN THE CREA PROGRAM

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Abstract

The PhD Program in Creativity and Social and Sustainable Innovation (CREA) at the University of Vigo in Spain, seeks to strengthen the University's contribution to priority research areas and global societal challenges through an innovative, transversal and creative educational approach. The program addresses key domains such as health, environment, communication, education and culture, and governance, with a particular focus on responding to emerging developments within the digital society. CREA is delivered entirely online, aiming to attract international talent and provide flexible access to advanced doctoral training aligned with contemporary educational transformations. This paper presents the design, implementation and continuous evolution of the program's e-learning methodology, highlighting its alignment with recent developments in digital education. The CREA doctoral program is supported by a fully virtual learning ecosystem developed by the University of Vigo, which includes a remote campus for synchronous online teaching and asynchronous access to recorded sessions, a digital platform for the management and organization of course content, and a comprehensive online system for academic and administrative monitoring through a virtual doctoral office. These digital infrastructures enable effective interaction, supervision and assessment in a fully online doctoral environment.

Keywords: *Doctoral program, digital innovation, e-learning, artificial intelligence, online education.*

1. Introduction

The doctoral program in Creativity, Social and Sustainable Innovation at the CREA (Campus of the University of Vigo in Spain), promotes inter- and transdisciplinarity between all the areas of knowledge taught on this campus. Highlights the value of cross-disciplinary doctoral work by integrating two different research lines. Candidates are supported by at least two mentors who provide specialized insights to strengthen the research. 24 theses have already been read (100% with the highest grade), the professors of the Program direct and/or belong to national and international research projects and groups of high scientific impact, several hundred publications of very high impact have been generated, and even some publications and activities have received awards, It is 100% virtual, enrolment fee of less than 400 euros per year, and more than 50 applications for access in the last two years: Increase of places maximum 20 to 24. You can write your thesis as a monograph or as a compendium of scientific articles (WOS/SCOPUS). If you want, you can also take with other qualifications: a) Industrial doctorate; b) International doctorate; c) A doctorate under co-supervision (UVIGO+ Foreign University – through an agreement between the two) (a double doctoral degree is obtained). It is virtual doctoral education: 100% online (secretary's office; academic management and tutoring; teaching-through UVIGO's own (MOOVI) teletraining platform (online); and a system of offices and virtual classrooms of the UVIGO (Remote Campus). Thesis dissertations are 100% online or face-to-face; MOOCs-UVIGO: Massive Online Open Courses (to expand knowledge) and online subjects from other UVIGO Doctoral program.

Considering this massive use of online teaching and its wide and diverse application in education, teachers, public administration, and governments need to be aware of the strengths and weaknesses of AI in learning, in order to be empowered, not dominated by technology, in digital citizenship education practices. This work focuses on many complex challenges posed by the connections between AI and education, specifically referring to PhD programs, to provide a holistic view in order to ensure that future developments and practices are genuinely used for the common good, to advance knowledge of their use

in education, critically analyzing whether they can mask the production of some errors, biases, overrepresentation or underrepresentation, and investigating the challenges and ethical considerations associated with their use, employing a systematic review of the literature.

2. Artificial intelligence in CREA doctoral program

In response to the specific requirements of virtual doctoral education, the program has also developed tailored protocols, guidelines and quality assurance processes for online thesis supervision, evaluation and virtual dissertation. These procedures ensure transparency, academic rigor and consistency with institutional and international doctoral standards, while taking advantage of the opportunities offered by digital technologies. Furthermore, the paper addresses emerging challenges associated with new developments in education, particularly the increasing use of Artificial Intelligence (AI) in learning and research contexts. Some researchers in the program wanted to get involved and started by conducting a literature review on these aspects. To carry out the systematic review of the literature, the methodological guidelines of PRISMA (Page et al., 2021; PRISMA, s.f.). in the Web of Science (WOS). The results were complemented with a manual search in Google Scholar. The strengths and limitations of AI tools are critically analyzed, including their potential impact on knowledge production, the risk of masking errors, reinforcing biases, or contributing to overrepresentation or underrepresentation of information. An extensive list of researchers has shown that machine learning models exhibit errors and social and political biases (Rozado, 2023; Dwivedi et al., 2023; Aydin y Karaarslan, 2023; Patel et.al., 2023); differences in the results according to ChatGPT (Feng et al., (2023); different response each time (Borji, 2023; Guo et al. 2023); or biased (Breazu y Katson, 2024; Winkel, 2024). A previous literature review (Ricoy-Casas et. al., 2024) highlights the increasing application of AI in the classroom in various areas; the increase in interest in the subject in all areas, especially in university education; and the diversity of studies that focus mainly on four aspects: a) the description and analysis of IA tools that can generate discrimination in underrepresented students; b) tools that can mitigate these results by verifying errors, biases and others; c) examples of applications and their usefulness by teachers themselves to improve inclusion; and d) public policies and processes in relation to the implementation of AI with an impact on the learning of underrepresented students. We have been able to observe: a) Their acceptability is different and related to previous academic training: (Li et. al., 2024) (Ünlüer, 2024); Some authors recommend the introduction of AI and expert systems into higher education curricula and teaching methods (Jarrah et. al., 2023; Esfandiari et. al., 2024). Some see it as a tool for scaffolding students' understanding and promoting critical thinking (Chen & Wang, 2021). Others believe Chat GPT can support differentiation and accommodate diverse learning needs (González et al., 2023). Additionally, teachers anticipate Chat GPT as a resource for language learning, cultural exchange, and global perspectives (Da Silva & Sutil, 2024); c) There are many different AI tools and applications for theses (Kulikowski et. al., 2023; Zhang, et. al., 2024).

Most of the permitted uses focus on: 1) AI-accelerated literature review; 2) Brainstorming and clarification of research questions and interventions; 3) Data management and analysis; 4) Generation of images and/or text; 5) AI-assisted coding, data visualization. However, while there is also often a requirement to explain the measures taken to mitigate bias and ensure academic rigor, this can reinforce the idea that the results obtained may not be 100% reliable or conclusive in many cases. Most major academic journals and publishers currently have policies on the use of generative AI in publications. These policies vary considerably. There is a growing consensus that generative AI tools do not meet the criteria for authorship of academic papers, as they cannot take responsibility or be held accountable for the papers submitted. Material generated by AI tools should not replace PhD candidates' own research and learning, nor misrepresent their understanding of the knowledge, concepts, and techniques used during the PhD. Some relevant publications were critical with generative AI (Nature, 2023).

3. Other conclusions

Some researchers warn about some errors produced by these systems for the development of scientific careers (Ginther et. al., 2024). Privacy and data security concerns related to student information and interactions are often raised (García & Rodríguez, 2022). Teachers worry about the reliability of Chat GPT's responses and the potential for misinformation (Lee & Kim, 2023). We have already seen how on occasion it produces limited and biased results which can exacerbate discrimination in some groups, and these systems also face dilemmas in the field of intellectual property, industrial property and even other ethical dilemmas (Helgeson et. al., 2025; Thorp, 2023; Stokel-Walker, 2023). It already represents a challenge for teachers, and ChatGPT appears as an author in research articles which many scientists disapprove of (Stokel-Walher, 2023). The responsible, ethical, and informed use of generative AI is permitted in doctoral research at most universities. In addition to corrective tools, it is crucial that

researchers discuss with their supervisors beforehand how they plan to use AI in their research, clearly detailing this approach in their work. This can foster a responsible, ethical, and informed approach (including responsible use from a privacy and data protection perspective). Therefore, the use of generative AI tools in the research and dissertation writing process should always be conducted with complete transparency. Furthermore, if a postgraduate unit permits the use of generative AI in research, it must ensure that the discipline-specific guidelines regarding the description of the methodology and appropriate references are clearly defined.

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IMPLEMENTING RESEARCH-BASED LEARNING TO ENHANCE COMPETENCIES IN INDUSTRIAL BIOTECHNOLOGY EDUCATION FOR CHEMICAL ENGINEERING STUDENTS

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Abstract

This project introduces a Research-Based Learning (RBL) approach in the Industrial Biotechnology course at the University of Jaén to enhance practical and research skills in Chemical Engineering students. Through hands-on, team-based projects using advanced lab equipment, students engage in authentic biotechnological challenges, fostering critical thinking, collaboration, and autonomy. Preliminary results show increased motivation, improved academic outcomes, and strengthened professional competencies. The model is designed to be scalable and transferable to other technical courses, with dissemination planned via publications and open educational resources.

Keywords: *Research-based learning, industrial biotechnology, engineering education, research competencies, active learning.*

1. Introduction

Nowadays, industrial biotechnology is a strategic pillar for sustainable development, with applications in the fields of agriculture, food, medicine, pharmacy, and bioremediation (Ozyigit et al., 2023). In this context, training chemical engineers with experimental, analytical, and research skills is essential.

Research-Based Learning (RBL) has established itself as an effective active methodology for promoting deep learning, critical thinking, and the development of scientific and professional skills in higher education (Bui & Khuu, 2020; Jungmann, 2019). In the field of biotechnology, previous experiences have shown that RBL improves conceptual understanding, attitudes toward science, and academic performance, especially in laboratory settings (Ramli & Bohori, 2025).

In this context, this study aims to integrate teaching and research in engineering education, promoting more applied, authentic teaching oriented toward solving real problems.

2. Design

The study was conducted using a method that combines observation and experimentation, using both quantitative and qualitative data. It was carried out in the Industrial Biotechnology course, within the Chemical Engineering degree program at the Higher Polytechnic School of Linares (University of Jaén). The activity was organized through research projects applied to real problems in the field of industrial biotechnology, following models previously used in engineering and biotechnology.

The teaching method combines theoretical classes with practical activities where students conduct research with the help of the teacher, in order to provide them with guidance on how to learn efficiently and avoid the difficulties that can arise from unguided learning (Jungmann, 2019; Wu et al., 2021).

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3. Objectives

The overall objective of the study is to evaluate the impact of RBL on the development of technical, research, and cross-disciplinary skills in chemical engineering students.

The specific objectives are:

- To improve the acquisition of experimental and analytical skills in industrial bioprocesses.
- Encourage the formulation of scientific questions, hypotheses, and experimental design.
- Increase student motivation, commitment, and autonomy.
- Develop cross-cutting skills such as teamwork, project management, and scientific communication.
- Evaluate student perception and the effectiveness of the model using structured assessment tools.

4. Methods

The implementation of the RBL takes place in laboratories equipped with fermenters, spectrophotometers, chromatographic systems, and other technologies commonly used in industrial biotechnology. Students work in teams to define problems, formulate hypotheses, design and execute experiments, analyze data, and communicate results through technical reports and oral presentations.

The methodological approach is based on guided research models validated in science and engineering education, which combine student autonomy with teacher supervision to ensure the quality of the training process (Wu et al., 2021).

The evaluation of the experience includes:

- Satisfaction and learning perception surveys.
- Analysis of academic performance.
- SWOT analysis of the implementation.
- Qualitative evaluation of reports and presentations to assess the development of research and communication skills.

5. Discussion

Preliminary results show that RBL improves motivation, active participation, and understanding of industrial bioprocesses. However, the analysis identified certain challenges that require strategic consideration (Figure 1).

Figure 1. SWOT Analysis of the Implementation of RBL in Industrial Biotechnology.

This SWOT analysis offers a strategic vision to maximize the strengths and opportunities of the ABI in Industrial Biotechnology, while addressing identified weaknesses and mitigating potential threats that could affect the continuity of the initiative.

6. Conclusions

The implementation of RBL in the Industrial Biotechnology course has proven to be an effective pedagogical strategy for strengthening technical, research, and cross-disciplinary skills in chemical engineering students. The model promotes a more applied education, aligned with the demands of the biotechnology sector and international standards in engineering education.

In addition, the proposed approach is presented as a scalable model that can be transferred to other experimental subjects and technical degrees. The dissemination of the results through scientific publications, conferences, and open educational resources will contribute to promoting the adoption of RBL in engineering education and strengthening the integration between teaching and research.

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EDUCATIONAL PROGRAM FOR TEACHING READING AND WRITING: ITEM CONSTRUCTION AND AGREEMENT AMONG JUDGES

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Abstract

Introduction: The number of students with literacy problems is growing in the Brazilian educational context, and one possible explanation for this exponential growth is the lack of literacy methods that emphasize teaching the alphabetic principle. *Aims:* describe the development of the Alfassilabando Educational Program to students from 1st, 2nd and 3rd grades of Elementary School and present the preliminar findings of validity. *Materials and methods:* This research was developed in two phases. Phase 1 focused on elaboration of items and criteria and Phase 2 focused validation by judgment of specialists. *Results:* The development of items and criteria for the Alfassilabando Educational Program for students with learning disabilities in grades 1-3 of Elementary School was possible through a review of national and international literature, which enabled the development of a program composed of five modules, with 18 activities distributed across four sessions. Content validation of the Alfassilabando Educational Program revealed moderate to poor agreement that only a pilot study could help in readjusting the instructions and the stimuli number in the program's activities. *Conclusion:* The Alfassilabando Educational Program can contribute to the development of reading and writing skills for students with learning disabilities of Elementary School.

Keywords: *Learning, syllabic approach, learning difficulties, literacy.*

1. Introduction

According to data released by INEP (Brazil, 2024), the results obtained by students demonstrated a serious and worrying situation regarding the performance of students in Basic Education, since more than 50% did not reach the expected level for the school year in relation to Portuguese Language and Mathematics skills, resulting in deficits in their development. More specifically, second-grade students in elementary school showed a lag in reading, implying a low level of text comprehension and difficulty decoding simple words. Another relevant finding was the comparison with previous editions, where the 2021 data demonstrated an accumulation of lag in reading fluency, reading comprehension, and logical-mathematical reasoning skills.

The data presented refers to the year 2021, because the data from the 2023 INEP report has not yet been released. However, it is important to emphasize that, although the context of the COVID-19 pandemic aggravated the development of reading and writing skills, especially for knowledge of the alphabet, metaphonological skills, and reading and writing skills, the delay in acquiring these skills was already evident before the pandemic (Santana, Capellini & Germano, 2022). This means that the number of students with literacy problems is growing in the Brazilian educational context, and one possible explanation for this exponential growth is the lack of literacy methods that emphasize teaching the alphabetic principle.

The lack of use of literacy methods based on scientific evidence means that the gaps generated in literacy hinder the development of basic skills necessary for reading, which allow the recognition of words and the development of comprehension, and this will have a negative impact on the teaching-learning process (Oliveira, Santos & Capellini, 2023).

Among the literacy methods based on scientific evidence, the phonics method and the multisensory method stand out for teaching reading and writing (Bowers & Ramsdell, 2023; Goldstein et al., 2017; McArthur et al., 2018). However, it is important to emphasize that being guided by scientific evidence is not about choosing a method, but rather proposing that the strategies used for teaching reading and writing be based on consistent scientific findings, as described by Snowling and Hulme (2013). Therefore, considering the use of methods that utilize the syllable as the initial basis of the literacy process would be

very appropriate, especially in countries that have more transparency than opacity in their writing system, such as Brazilian Portuguese.

This is because the syllable constitutes a fundamental structure for phonological knowledge (Alves, 2017) and, therefore, is a grammatical unit that structures phonological knowledge (Freitas & Santos, 2001), that is, metaphonological ability fulfills the function of guiding the capacity to identify the segmentation of words into syllables and sound segments, and consequently the letter, for the establishment of the letter-sound relationship.

Based on the above, this work is justified by the need to develop supplementary educational material for literacy that includes multiple teaching strategies, organized in a way that promotes access and retention of different student profiles in the literacy process. Thus, the aim is to offer a pedagogical alternative that uses a syllabic, phonic, and multisensory approach for the systematic, instructional, and structured teaching of reading and writing.

2. Objective

The objective of this study was to describe the development of the Alfassilabando Educational Program to students from 1st, 2nd and 3rd grades of Elementary School and present the preliminar findings of validity.

3. Methods

This study was approved by the Research Ethics Committee of the Faculty of Philosophy and Sciences of the São Paulo State University “Júlio de Mesquita Filho” - FFC/UNESP - Marília-SP, under number 88225625.0.0000.5406.

This research was developed in two phases, with phase 1 focused on constructing the items and criteria of the Alfassilabando Educational Program for students in the 1st to 3rd years of Elementary School I with learning difficulties, and phase 2 focused on validating the content of the Alfassilabando Educational Program through consultation with specialists.

Phase 1 of the study was developed based on the following question: "What are the most commonly used literacy strategies and methods?" The databases chosen for the search of scientific articles were PubMed and SciELO, initially using the combination of keywords in English, "Reading", "literacy" and "children", and in Portuguese “dificuldades de aprendizagem”, “alfabetização” e “crianças”. The data collection covered a period of ten years, from 2015 to 2025, as the objective was to identify articles that answered the guiding question and addressed the theme established by the keywords.

In the first stage of screening, 369 articles were identified. After reading the titles and abstracts, a significant portion was excluded for not meeting the research criteria. Subsequently, the full texts of the remaining articles were read, resulting in the final selection of only five studies that actually addressed the proposed topic.

Based on the reading of these five texts, the Alfassilabando Educational Program for teaching reading and writing was developed using metaphonological multisensory skills of syllabic and phonemic manipulation associated with segmentation and spelling tasks for the development of reading and writing in students from the 1st to the 3rd year of literacy with learning difficulties.

In phase 2 of the study, the content of the Alfassilabando Educational Program was validated. Ten judges were consulted for this purpose: three pedagogues and seven speech therapists. The judges' role was to critically analyze whether the program's items were sufficient to intervene in reading and writing skills.

To measure the statistical agreement between the judges, Fleiss' Kappa statistical analysis was used for each aspect of the program developed, adopting a significance level of 0.05 (5%).

4. Results and discussion

Based on the linking of strategies with the use of letters and syllables for the formation of words for reading and writing in phase 1 of this study, the Alfassilabando Educational Program was composed of 5 Modules, distributed according to the five oral vowels (A-E-I-O-U). Each module consisted of 18 activities distributed over 4 meetings, with the last meeting dedicated to carrying out the learning verification activity, through the use of writing under word dictation.

The results of phase 1 of this study demonstrated that despite the limited number of systematic investigations on the syllabic method, there is evidence that the use of syllabic strategies is important for the development of reading and writing, since these strategies are present in most studies with the phonics and multisensory approach. Therefore, the use of syllabic instruction is a promising and fundamental alternative for promoting effective literacy.

This disparity in the number of studies found when comparing syllabic instruction with phonics and multisensory instruction highlights the need to reformulate pedagogical practices, even if not based exclusively on syllabic methods, but rather on the union between phonics, multisensory, and syllabic approaches, encouraging the adoption of strategies supported by scientific evidence and consistent with the principles of reading science, as proposed by the Alfassilabando Educational Program.

The results of phase 2 of this study showed that the analysis of the judges' agreement revealed variability in responses regarding the items related to the composition of the objectives, description of the activities, composition of the instructions, order of activities, total number of activities in the modules, number of stimuli per meeting and per module, also indicating this same variability in responses for the clarity of the category statement and for the number of items that make up the category, resulting in poor agreement.

When analyzing this judges' agreement, it is possible to observe that perhaps the readjustment of these items can be carried out after the pilot study, since only with the study of applicability will it be possible to reorganize the program, as these items that proved inconsistent in the judges' analysis may or may not be restructured depending on the responses of students with learning difficulties from the 1st to the 3rd years of Elementary School I.

We conclude this study with the perspective that the limitations of this study may become nonexistent after the pilot study is carried out, since any possible doubts about the suitability of the Alfassilabando Program will be resolved through its applicability.

5. Conclusion

The development of items and criteria for the Alfassilabando Educational Program for students in grades 1 through 3 of Elementary School I with learning difficulties was made possible through a review of national and international literature, which allowed for the creation of a program composed of 5 modules, with 18 activities distributed across 4 meetings.

The content validation of the Alfassilabando Educational Program through consultation with experts revealed moderate to poor agreement, suggesting that only conducting a pilot study will help in readjusting the instructions and the number of stimuli in the program's activities.

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ROLLING DICE, BUILDING FUTURES: USING BOARD GAME TO ENHANCE CAREER PLANNING

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Abstract

Higher education institutions face increasing challenges in preparing students for complex and uncertain labour markets. Although career development learning is widely promoted in higher education policy, it often remains weakly embedded in university curricula, particularly in theory-driven programmes. As a result, many students experience difficulties in applying academic knowledge to real-life career planning, financial decision-making, and work-related problem-solving. This study presents an innovative analogue board game, Study Hard, Work Hard!, designed to support career development learning through experiential and playful pedagogy in higher education. The game simulates realistic student life situations such as budgeting, student employment, scholarship opportunities, job interviews, and time management dilemmas. It aims to develop employability-related competences including decision-making, collaboration, communication, reflection, and financial awareness. The board game was implemented within a university course focusing on career preparation at a Hungarian higher education institution. A total of 60 undergraduate students from diverse disciplinary backgrounds participated in a facilitated gameplay session. Data was collected using a structured post-intervention questionnaire measuring motivation, engagement, collaboration, perceived learning outcomes, and the realism of the scenarios, complemented by open-ended reflections. Findings indicate that students perceived the board game as highly engaging and educationally valuable. Participants reported increased awareness of career-related choices, financial challenges, and the complexity of balancing work and study. The most positively evaluated aspects were the realism of the situations, opportunities for reflection, and the development of employability-related skills in a supportive learning environment. The results suggest that board game-based pedagogy offers a practical and adaptable approach for integrating career development learning into higher education curricula while enhancing student engagement.

Keywords: *Career development learning, employability, board games, pedagogical innovation, higher education.*

1. Theoretical background

1.1. Career development learning and employability

Higher education increasingly prioritises employability and skill development to meet changing labour market demands (Jackson & Bridgstock, 2021; Healy et al., 2020). This has driven a shift toward experiential approaches, including problem-based, project-based, and work-integrated learning, which enhances active engagement and practical skills (European Commission, 2020). Career development learning (CDL) is increasingly embedded in curricula to support employability (Dean et al., 2022; Bridgstock et al., 2019).

CDL develops self-awareness, labour market understanding, and transferable skills, enabling informed career decisions (Bridgstock, 2009; Tomlinson, 2017). Early integration strengthens career awareness and professional identity while reducing uncertainty and disengagement (Nyström et al., 2008). However, implementation is constrained by overloaded curricula and limited institutional focus on career competencies (Bridgstock et al., 2019).

Although educators are increasingly open to CDL, many lack confidence or view it as outside their core role (Dean et al., 2022). CDL extends beyond CV writing to identity formation, reflection, and career planning skills essential for today's labour market (Bridgstock, 2009).

1.2. Board games in higher education

Over the past decade, higher education has increasingly shifted from traditional instructor-led teaching toward student-centred, active learning approaches that promote autonomy, transferable skills, and "learning how to learn" in response to rapidly changing societal needs (Khalaf & Zin, 2018; Manzano-León et al., 2021). Research shows that board games can effectively simplify complex topics, increase motivation, and improve learning outcomes. They have also been used to develop specific skills such as time management, and in some cases have outperformed traditional teaching methods in long-term impact. Applications in higher education include health sciences, business, and teacher education, supporting skills such as teamwork, engagement, and reflection (Brydges & Dembinski, 2019; Karbownik et al., 2016; Radzi et al., 2020; Vijayakumar & Kulkarni, 2020; Viray, 2016). Student- or educator-designed games further enhance reflective and learner-centred teaching approaches (Brydges & Dembinski, 2019).

Overall, board games remain an underexplored tool in Hungarian higher education. This gap underpins the development of Study Hard, Work Hard!, which uses accessible game elements (board, cards, play money, role prompts) to support active learning, creativity, collaboration, and competence development through low-cost, experiential pedagogy.

2. Study Hard, Work Hard! Board game

The Study Hard, Work Hard! board game was developed based on previous findings on student employment and institutional needs for stronger experiential and practice-based learning (Kocsis & Pusztai 2025). It responds to the need for improved career support, financial literacy, and soft skill development by simulating real student life situations using empirical data from Hungarian and international studies (e.g. Eurostudent data; Kocsis & Pusztai 2025).

The game is designed for up to six players (or pairs) and follows a 40-field board structure where participants progress via dice rolls. Players start with 250 EUR and navigate student life decisions such as housing, budgeting, studying, and employment. There is no single winner, as the focus is on experiential learning and reflection rather than competition.

Gameplay combines chance and structured learning tasks. Players encounter four main task types: (1) quiz cards based on labour market and student data, (2) decision-making dilemmas reflecting real opportunity costs, (3) task cards requiring practical and creative responses (e.g. CV writing, problem-solving), and (4) interview questions simulating job interviews. Financial rewards reinforce learning and decision consequences. Each task type targets specific competencies: knowledge acquisition, critical thinking, communication, self-awareness, and financial literacy. Interview and reflection-based tasks particularly support metacognitive development and career identity formation. The integration of real labour market data ensures authenticity, while peer interaction encourages discussion and collaborative learning.

Overall, the game transforms complex career-related challenges into a low-risk, engaging learning environment that supports experiential learning and competence development through active participation.

3. Research and feedback

A total of 60 undergraduate students from various disciplines participated in the study. Participants were enrolled in a career preparation course at a Hungarian higher education institution. Data was collected using a post-intervention questionnaire combining Likert-scale items and open-ended questions. The instrument measured engagement and motivation, perceived realism of scenarios, collaboration and perceived learning outcomes. Quantitative data were analysed using descriptive statistics, while qualitative responses were analysed using thematic analysis to identify recurring patterns in student experiences.

Findings indicate high levels of engagement across participants. Students reported that the interactive and competitive elements of the board game increased their motivation to actively participate in learning activities. Participants indicated that the game supported their understanding of career-related decision-making. Many students highlighted improved awareness of financial planning challenges and the consequences of balancing study and work responsibilities. The collaborative nature of gameplay fostered peer learning and communication. Students reported that group-based decision-making encouraged discussion, negotiation, and shared reflection. The simulation of real-life scenarios was identified as one of the most valuable aspects of the intervention. Students perceived the situations as realistic and relevant. The findings suggest that analogue board games can function as effective tools for integrating career development learning into higher education curricula. The approach supports active learning, reflection, and skill development in a structured yet flexible format.

4. Conclusions

The Study Hard, Work Hard! board game provided students with an engaging, experiential learning environment that enhanced their understanding of employability-related challenges. The results highlight the potential of analogue game-based methods as scalable and low-cost pedagogical innovations that can complement traditional teaching approaches. Future research should explore longitudinal effects of such interventions.

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FLIPPED WEBINARS FOR ONLINE PSYCHOLOGY STUDENTS: IS ATTENDANCE AN APPROPRIATE QUALITY INDICATOR?

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Abstract

Interaction and collaboration support student satisfaction and learning in online education, yet participation in synchronous activities can be challenging for online students due to work and family obligations. An experimental development project was conducted, in which a flexible, voluntary flipped webinar series was implemented for online psychology students over three terms. The aim was to support student motivation through active and collaborative learning. This paper reports findings from one component of the data collection, namely a student evaluation (n = 47, response rate: 26%) including both quantitative and qualitative data. Results revealed high perceived learning and moderate perceived social benefit. However, attendance remained low across the terms, at levels comparable to other voluntary synchronous webinar series. Low attendance raises questions about how the effects of flexible, synchronous teaching interventions should be interpreted, and this paper examines the role of attendance as a quality indicator in online education. Self-determination theory (SDT) was used as a conceptual framework for the pedagogical design of the flipped webinar series. Three single-item statements were adapted, translated, and contextually adjusted from an established SDT instrument to serve as exploratory indicators of need satisfaction. Results indicate that the needs for autonomy and competence were generally supported. Attendance was associated with lower perceived autonomy and higher perceived relatedness. The findings suggest that perceived need satisfaction may function as a supplementary quality indicator.

Keywords: *Flipped classroom, higher education, online learning, quality measures, self-determination theory.*

1. Introduction

Interacting and collaborating with peers and teachers has been shown to be important for online students' satisfaction (Wallace, 2003) and learning (Regmi & Jones, 2020). However, participating in a learning community can be challenging for online students due to competing commitments such as work and family (Hart, 2012). In response, a flexible flipped webinar series was implemented for online psychology students over three terms. The aim was to support student motivation through active and collaborative learning. Attendance and student evaluation data were used to assess the quality of the intervention as part of an experimental development project.

1.1. Conceptual framework: Self-determination theory

Self-determination theory (SDT) served as a framework to support the pedagogical design of the flipped webinar series. According to SDT, the needs for autonomy, competence, and relatedness must be satisfied for autonomous motivation to thrive (Ryan & Deci, 2000). Autonomy, defined as the experience of choice and volition, informed the decision to offer the webinar series on a voluntary basis.

2. Teaching design

The respondents were enrolled in a Developmental Psychology course at a Norwegian university college offering highly flexible study programmes, characterised by few compulsory activities. Three cohorts of online students enrolled in Developmental Psychology were invited to join voluntary flipped classroom webinars. Flipped classroom is a teaching model characterised by flexibility (Akçayir & Akçayir, 2018), in which students prepare in advance and class time is used for active and collaborative learning. Flipped classroom sessions usually take place in person, whereas the respondents took part in a fully digital version. Preparatory work could be carried out at any chosen time.

3. Methods

Attendance was recorded by the teacher. Quantitative and qualitative data were collected across terms through an anonymous online questionnaire distributed to all enrolled online students in Developmental Psychology. This paper focuses on the evaluation from autumn 2024 (n = 47, response rate: 26%), when five voluntary flipped webinars were offered.

The student evaluation included quantitative measures regarding perceived academic and social outcomes, and open-ended questions on strengths and limitations of the webinar series. Three single-item statements (i.e., items 1, 12, and 15) assessing autonomy, competence, and relatedness were adapted from an established SDT instrument (Ilardi et al., 1993) to serve as exploratory indicators of need satisfaction within the course. The items were translated into Norwegian and adapted to the higher education setting. The three items were: "I feel that I have a strong influence over my own study situation", "On most study days, I experience a sense of accomplishment", and "Fellow students care about me." The statements were rated on a seven-point scale (1-7), with 7 indicating "very true".

4. Results

In the student evaluation of the flipped classroom series, 71% reported a high level of academic outcome, 26% a moderate level and 3% a low level. Regarding social benefit, 26% reported a high level, 35% a moderate level, and 38% a low level. The qualitative feedback was predominantly positive. Overall attendance remained low (12% across terms). Mean scores were 6.0 (SD = 1.1) for autonomy, 5.2 (SD = 1.2) for competence, and 3.7 (SD = 1.8) for relatedness. A Spearman's rank-order correlation revealed a significant negative association between attendance and perceived autonomy ($\rho = -.37$, $p < .05$) and a positive association between attendance and relatedness ($\rho = .33$, $p < .05$). There was no significant association between attendance and competence.

5. Discussion

The student evaluation showed high levels of perceived academic learning and a moderate degree of perceived social benefit, which can be interpreted as positive given the duration of the webinar series.

The respondents reported a very high mean score on perceived autonomy and a relatively high score on competence, suggesting that they generally experienced choice and mastery within the course. Relatedness received the lowest mean score. This finding aligns with previous research identifying relatedness as the most difficult need to support in online learning contexts (Salikhova, Lynch, & Salikhova, 2020).

Attendance was associated with lower perceived autonomy and higher perceived relatedness (Spearman's ρ). In line with Funder and Ozer (2019), these correlations can be considered large. However, given the limited sample size and the use of single-item measures, which may affect reliability and construct validity, the findings should be interpreted with caution. Furthermore, correlation analyses do not establish causality.

5.1. The role of attendance and perceived need satisfaction as quality indicators

The results suggest that the needs for autonomy and competence were supported. The negative association between attendance and autonomy might reflect that students who experience high degrees of autonomy also score high on self-regulation, making attendance in synchronous teaching appear less important. The positive association between attendance and relatedness might suggest a positive social benefit from collaborating with peers, but it can also reflect that socially oriented students may be more likely to participate in collaborative teaching activities.

While respondents expressed satisfaction with the webinar series, overall attendance remained low. Comparable attendance levels have been reported in other voluntary synchronous webinar series. Low attendance raises concerns regarding the interpretation of the effects of flexible synchronous teaching interventions and calls into question the allocation of teaching time and resources.

Although *attendance* is typically not presented as an explicit indicator of quality in online education, *engagement* is implicit in quality indicators such as interaction with peers and with teachers (Hafeez, Naureen, & Sultan, 2022; Valai, Schmidt-Crawford, & Moore, 2019), and engagement in synchronous learning tasks (Valai et al., 2019). Engagement may constitute a more meaningful indicator of quality. However, in practice, attendance is often a more accessible source of data and is likely to serve as an important – if not decisive – factor in decisions regarding the continuation of digital synchronous teaching interventions.

One interpretation of low attendance is that it may be of limited relevance if turnout is sufficient to support meaningful interaction and collaboration. From an SDT perspective, keeping attendance voluntary may support the need for autonomy. Furthermore, making attendance compulsory is no guarantee of active engagement. Conversely, low attendance may hinder the facilitation of relatedness, one of the key drivers of autonomous motivation (Ryan & Deci, 2000). One way to increase attendance is to make it compulsory, which may support relatedness but simultaneously undermine autonomy. This highlights a potential tension between the facilitation of these needs in flexible synchronous teaching.

Taken together, the findings suggest that attendance should not be used as a stand-alone indicator of quality. Rather, perceived need satisfaction may serve as a supplementary quality indicator when evaluating flexible synchronous teaching.

6. Conclusions

While the findings suggest that the fully digital flipped webinar series was useful both academically and socially, and that the needs for autonomy and competence were supported within the course, attendance remained low. Keeping the webinar series voluntary may have supported autonomy, but it may also have limited the facilitation of relatedness. Thus, the findings highlight a potential tension between the facilitation of these needs in voluntary synchronous online teaching.

The findings underscore the need for a broader critical debate regarding the role of attendance as a quality indicator in online education. Based on SDT, perceived need satisfaction may serve as a supplementary quality indicator.

The results should be interpreted with caution due to the moderate response rate and small sample size. The use of single-item measures may limit reliability and validity. Furthermore, correlation analyses do not establish causality.

Further research is needed to examine academic and social outcomes, as well as need satisfaction, in fully digital flipped classrooms. Future studies should include larger samples and multi-item scales. An important avenue would be to explore the characteristics of students who choose to attend voluntary synchronous activities.

Given online students' need for flexibility, the flipped webinar series will remain a voluntary option in Developmental Psychology, provided that class size permits effective collaborative groups.

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DIGITAL TOOL USE AND MATHEMATICS PERFORMANCE: EVIDENCE FROM PISA 2022

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Abstract

This study investigates the impact of students' digital background factors on mathematical achievement using data from the 2022 PISA assessment. The analysis focuses on 15-year-old students from Austria, Estonia, and Hungary with particular attention given to the interplay between home financial conditions, ICT availability and usage, digital attitudes, and mathematics performance. Drawing on student questionnaire responses, we constructed composite indices and factor scores representing digital access, usage frequency, and digital competence at both home and school settings. Descriptive statistics, ANOVA, and linear regression models were applied to explore the relationships between digital background variables and students' mathematics proficiency scores. The results reveal that home financial status consistently predicts higher achievement across all three countries, whereas the frequency of school-based ICT use shows a negative correlation with performance. Conversely, home-based ICT usage and positive attitudes towards online platforms correlate with higher mathematics outcomes. The Estonian data challenge the initial hypothesis of a country-specific positive effect of ICT usage in schools, suggesting instead that the quality and context of digital integration matter more than frequency. The findings also highlight the importance of learning orientation and student motivation in shaping mathematics performance. Despite some methodological limitations – such as the cross-sectional nature of the data and reliance on self-reported measures – the study offers reliable insights into how digital background factors influence academic outcomes. The results underscore the need for more effective integration of ICT tools in classrooms, informed by students' learning habits and preferences.

Keywords: *Digital background, mathematics achievement, PISA 2022, ICT usage.*

1. Introduction

The emergence of the information society in the 1990s transformed how knowledge is produced, accessed, and used in education. While some scholars emphasized structural change, others highlighted continuity, arguing that developments in information processing do not necessarily reshape social foundations (Castells, 1996). With the spread of digital technologies, especially the Internet, new forms of learning and knowledge access have emerged, reshaping educational environments (DiMaggio & Hargittai, 2001).

Digital tools can enhance creativity, collaboration, and access to information, but their effectiveness depends on pedagogical integration and teacher preparedness. Without these, ICT use may even negatively affect student performance. Research on digital inequality also shows that disparities extend beyond access to include competencies, usage patterns, and social support (DiMaggio & Hargittai, 2001; Erdős, 2015).

This study examines the relationship between digital background factors and mathematical achievement using PISA 2022 data from Austria, Estonia, and Hungary, providing a comparative perspective. Special attention is given to Estonia, often referred to as the "Estonian miracle" due to its high performance and advanced digitalization.

Mathematical competence is selected as the main outcome variable because of its role in problem-solving and real-life decision-making, and its relatively limited exploration in relation to digital background factors. Understanding how ICT usage and digital competencies influence performance is essential in increasingly digitalized education.

2. The role of the educational environment in the development of student competencies

Research on educational effectiveness has long examined the relationship between school resources and student performance, often conceptualizing achievement as an output and institutional factors

as inputs. While early studies found only limited effects of school-level variables, later analyses have confirmed that factors such as school infrastructure, location, and teacher quality do influence student outcomes (Knowledge and Skills for Life, 2001; Lannert, 2006). In addition, family background – particularly parental education – remains a strong determinant, with its impact varying across countries.

With the increasing integration of digital technologies, the role of the educational environment has become more complex. Evidence suggests that ICT tools can make teaching more engaging and support the development of problem-solving and self-directed learning skills; however, their impact on academic performance remains inconsistent (Antal et al., 2015). Cross-national analyses indicate that higher-performing education systems tend to use ICT more effectively, often supported by teachers who are confident and open to digital innovation (Lannert, 2014). At the same time, empirical findings highlight a paradox: while moderate and purposeful use of digital tools may support learning, excessive or unstructured use is often associated with lower achievement (Erdős, 2015). Large-scale studies and experimental programmes have consistently shown that the mere availability of digital devices does not lead to improved academic outcomes (Cristia et al., 2012; Beuermann et al., 2015).

Overall, the literature suggests that the effectiveness of ICT in education depends not on access alone, but on its pedagogically meaningful integration and the preparedness of teachers to use these tools effectively.

3. Research questions and hypotheses

This study investigates the relationship between students' digital background and their mathematical performance in the PISA 2022 assessment. It aims to explore how access to ICT tools, patterns of use, digital competencies, and attitudes toward digital technologies influence achievement across Austria, Estonia, and Hungary. Particular attention is given to cross-country differences and to whether the "Estonian miracle" reflects more effective digital integration in education. Based on these research questions, the following hypotheses are formulated:

H1. Students with a stronger digital background achieve higher mathematics competency scores in all three countries.

H2. Higher levels of digital competence are associated with better mathematics performance.

H3. Positive attitudes toward school-based ICT use are associated with higher performance, while more intensive or less structured use at home is associated with lower performance.

H4. School-based ICT use is negatively associated with performance in Austria and Hungary but positively associated in Estonia.

4. Methodological background and database of the study

This study is based on data from the PISA 2022 assessment, using the Student Questionnaire Database to analyze the relationship between students' digital background and mathematical performance. The sample includes students from Austria (n=6151), Estonia (n=6392), and Hungary (n=6198), resulting in a total of 18,741 participants.

Mathematical achievement was measured using plausible values provided by PISA, while digital background variables were constructed from questionnaire data. These variables capture multiple dimensions, including home financial status, ICT availability, ICT usage at home and at school, digital competencies, and attitudes towards digital technologies.

Composite indices were created for financial background and ICT access, and factor analysis was used to identify key dimensions of digital background. The analysis distinguishes between home, school, and individual-level factors. All variables were standardized and categorized into terciles (lower, middle, upper groups) to enable comparative analysis. Statistical methods included descriptive analysis, ANOVA, and linear regression models to examine the relationships between digital background factors and mathematical performance.

5. Empirical results

The results show that home financial status is one of the strongest predictors of mathematical performance across all three countries, with substantial performance gaps between students from lower and higher socioeconomic backgrounds. This effect is somewhat weaker in Estonia, suggesting a more balanced education system.

Regarding ICT usage, a clear pattern emerges: school-based ICT use is generally negatively associated with performance, while home ICT use shows a positive relationship. Students who use digital

tools moderately or less frequently in school tend to achieve better results, whereas more intensive use is often linked to lower performance. Digital competencies reveal contrasting effects. While the use of online platforms is positively associated with achievement, content creation shows a negative relationship, indicating that not all forms of digital engagement support mathematical learning equally. In addition, stronger support for strict ICT control in schools is associated with lower performance, whereas students favoring less restrictive environments tend to achieve better results. Finally, learning orientation emerges as a consistently strong positive factor, with more motivated students achieving significantly higher scores.

Regression analyses confirm these patterns, highlighting positive effects of home-related factors and learning motivation, and negative effects of school-based ICT use and certain forms of digital engagement.

6. Conclusion

The findings confirm that home financial background is one of the strongest determinants of mathematical performance across all three countries, while the effect of digital access is less pronounced, highlighting the continued importance of socioeconomic inequalities.

A consistent pattern appears in ICT usage: school-based use is negatively associated with performance, whereas home use shows a positive relationship. This suggests that digital tools are more effective in flexible, self-directed contexts, while classroom integration is not always pedagogically optimal. Students using ICT less frequently during mathematics lessons tend to perform better.

Differences also emerge in digital competencies. The use of online platforms is positively related to achievement, while content creation shows a negative association, indicating that not all forms of digital engagement equally support learning. The results do not support the assumption that higher levels of digitalization lead to better outcomes. Although Estonia performs at a high level, this is not explained by ICT frequency, suggesting that the quality of integration matters more than usage.

Regarding attitudes, strong support for strict ICT control is linked to lower performance, while learning orientation is consistently associated with higher achievement across all countries.

Hypothesis testing shows that H1 is confirmed, H2 is partially confirmed (only certain digital competencies have positive effects), while H3 and H4 are not supported.

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CHATGPT AS A LANGUAGE TRAINER FOR ENHANCING THE INTERACTION SKILLS OF GERMAN LEARNERS IN JAPAN

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Abstract

This study explores the usefulness of ChatGPT for improving L2 German learners' communicative skills and for raising awareness of the evolving literacy demands associated with AI use. Participants were B1-level students at a Japanese university who completed six communicative tasks with ChatGPT based on scenarios from their textbook, including a shopping conversation, a private dinner invitation, and a job interview. The tasks were designed to allow learners to apply expressions introduced in the textbook. To support task completion, students received step-by-step instructions as well as prompts specifying the situation and for resolving linguistic difficulties and obtaining feedback on their output. The tasks were completed as homework. Data consisted of transcripts of student–ChatGPT interactions and a post-task survey including Likert-scale and open-ended items. Quantitative data were analysed descriptively, and qualitative content analysis was applied to open-ended responses. The study addressed three research questions: what difficulties students encounter when completing communicative ChatGPT tasks as homework, how useful they perceive such tasks for learning German, and how the tasks could be improved to complement textbook-based instruction. Results indicate that students generally enjoyed using AI and valued the opportunity to practice interactions and review information at their own pace. They perceived the tasks as helpful for receiving feedback, improving reading and writing skills, and reinforcing vocabulary and grammar. However, the study also revealed misunderstandings and uncertainty about the accuracy of AI-generated information. These findings highlight the importance of providing learners with adequate linguistic and technical support when integrating AI into homework assignments.

Keywords: *Artificial Intelligence, German, computer mediated communication, task-based learning.*

1. Introduction

Since the launch of *ChatGPT* in late 2022, its integration into formal L2 instruction has been examined in numerous studies. For example, it has been found that using ChatGPT may facilitate the implementation of learner-centred, practice-oriented teaching approaches, such as Task-Based Language Teaching (Kim et al., 2023). By providing corrective feedback on learners' L2 output, the tool may help improve learners' L2 skills. Thanks to its versatile affordances, using this tool in formal L2 instruction may inspire students to engage in beyond-class L2 practice (Liu, 2023) and foster their autonomy for L2 learning (Agustini, 2023).

Previous studies on the use of AI in the field of L2 German have primarily focused on its application in completing academic assignments and developing writing skills (Grein, 2025), as well as on the integration of AI-generated texts into L2 German instruction (Hartmann, 2024). The exploratory case study presented here examines how AI can be integrated into German as a Foreign Language instruction in international contexts, with particular emphasis on fostering target-language interaction skills outside the L2 classroom.

To this end, a teaching concept was developed in which textbook-based instruction is supplemented by interactive tasks to be completed by using ChatGPT. This study investigates the potential of ChatGPT to enhance L2 German learners' communicative skills and to raise awareness of the evolving literacy demands associated with AI use. It addresses the following three research questions:

(1) What difficulties do learners encounter when performing communicative ChatGPT-based tasks as homework?
(2) How useful are such tasks for L2 German learning?
(3) How can AI-based tasks meaningfully complement textbook-based German instruction?

2. Participants and procedures

This study was conducted in an L2 German class with three participants (CEFR level B1) in their third year of study at Hiroshima University. Participants completed six communicative tasks with ChatGPT based on scenarios from their textbook, including *(1) describing a person, (2) talking about work experience, (3) expressing ideas about the future, (4) expressing career wishes, (5) holding a conversation during a private dinner invitation,* and *(6) conducting a sales dialogue in a specialty store.* The tasks were designed to enable the application of previously introduced textbook expressions. As the tasks were assigned as homework, initial in-class instruction was provided, including explanations and model examples of task completion. For the six tasks under investigation, participants received step-by-step instructions via the Moodle platform, along with L2 prompts that specified the task scenarios and supported both the resolution of linguistic difficulties and feedback on learners' output.

The data analysed in this study consists of transcripts of student–ChatGPT interactions and a post-task survey. The chat transcripts were analysed qualitatively. An initial review was conducted to examine learner responses to ChatGPT's prompts, the degree of conversational naturalness, instances and sources of misunderstandings, and the extent to which the prompts supported successful task completion. The post-task survey captured the language (German/Japanese) and modality (spoken/written) of learners' input, the time required for task completion, the perceived suitability of prompts, and reported comprehension difficulties. Participants also evaluated task difficulty, the usefulness for specific language skills, as well as their willingness to use AI tools for L2 learning in the future. Responses were collected using five-point Likert scales ranging from +2 to –2, supplemented by open-ended comments. The data were analysed both qualitatively and quantitatively and integrated with the analysis of the chat transcripts.

3. Results

As the analysis of the chat transcripts revealed, learners were generally able to complete the tasks successfully. Since ChatGPT adapted to their L2 proficiency level, they had no major difficulties understanding questions posed in the target language; however, they sometimes struggled to formulate their responses. When learners hesitated in providing an answer, ChatGPT first prompted them again to respond. If they still did not reply, it provided answer options or useful sentence starters.

Another function of the task was to raise learners' awareness of errors in their language use. This was initially intended to be facilitated by a predefined prompt, which learners were to use at the end of the interaction. However, ChatGPT appeared to recognise that the interaction constituted a language-learning task and therefore provided immediate correction of linguistic errors along with corresponding explanations during the interaction. This, however, made the dialogues appear rather artificial, as the conversation was repeatedly interrupted by linguistic digressions. As a result, direct responses to learners' utterances were relatively rare. Overall, ChatGPT reliably identified learners' errors and provided appropriate corrections and explanations. The corrections also indicated that ChatGPT not only addressed formal linguistic errors but also attended to aspects of naturalness.

The other prompts provided in the task description also proved to be useful. When learners found ChatGPT's responses too long, they requested shorter versions; when something was unclear, they asked for further explanations; and when they were overwhelmed by overly difficult L2 output, they requested translations. Towards the end of the interaction, ChatGPT frequently asked whether it should continue the practice, provide further grammar explanations or exercises, or generate a corrected version of the entire conversation.

As the survey results indicate, students generally enjoyed using AI and valued the opportunity to practice interaction and review information at their own pace. Participants required on average 20 to 30 minutes to complete the tasks, with completion times ranging from under five minutes to up to 45 minutes. The computer appeared to be the preferred device for task completion. Prompts were entered exclusively via keyboard, and ChatGPT's output was presented almost entirely in written form. To resolve language difficulties, learners frequently used dictionaries, textbooks, and ChatGPT itself.

With regard to perceived benefits for L2 learning, participants rated the six tasks on a five-point scale (–2, –1, 0, +1, +2). The values presented in Table 1 represent the mean scores derived from these ratings, where +2 indicates 'very helpful' and –2 indicates 'not helpful at all'. As shown in Table 1, students perceived the tasks as particularly helpful for receiving corrective feedback, as well as for improving reading and writing skills and reinforcing grammatical structures. To some extent, they also reported benefits in terms of vocabulary expansion and reading comprehension. However, the tasks were not considered particularly helpful for practicing oral L2 production or listening comprehension. This is likely because learners used only the keyboard for L2 input and were exposed exclusively to ChatGPT's written output.

Table 1. Benefits for L2 Learning.

	1	2	3	4	5	6	∅
Feedback on L2 errors	1,7	2,0	1,3	2	2	1,7	1,8
Development of interaction skills	1,3	1,7	1,7	2	1,7	1,7	1,7
Grammar acquisition	1,7	1,7	2,0	1,3	1,7	1,7	1,7
Improvement of writing skills	1,7	1,7	1,7	1,7	1,3	1,7	1,6
Vocabulary expansion	1,3	1,0	1,3	1,3	1,3	1,3	1,3
Practicing reading comprehension	1,0	0,3	1,7	1,7	1,7	1,0	1,2
Practicing language production	–0,3	–0,3	0,3	0,3	0,7	0,3	0,2
Practicing listening comprehension	–1,0	–1,0	–1,0	–1,5	–0,3	–1,7	–1,1

4. Summary and discussion

This study investigated the use of ChatGPT as a language training tool for enhancing L2 German interaction skills in a task-based homework setting. With regard to the three research questions posed at the outset, the following results were obtained.

Regarding the difficulties learners encountered when performing communicative ChatGPT-based tasks as homework, the results indicate that participants were generally able to complete the tasks successfully. While ChatGPT adapted well to learners' proficiency level, learners sometimes experienced difficulties in formulating responses in German. In addition, interaction was at times disrupted by ChatGPT's immediate corrective feedback, which shifted the focus from meaning-oriented communication to form-focused commentary. Another challenge concerned learners' uncertainty about the reliability of AI-generated content, suggesting the need for stronger development of critical evaluation skills in AI-mediated learning.

Regarding the perceived usefulness of the tasks for L2 German learning, the results suggest that participants viewed the ChatGPT-supported activities positively overall. In particular, learners valued corrective feedback, which they associated with improvements in grammar, writing, and vocabulary acquisition. The tasks also supported reading comprehension and allowed learners to engage with target structures at their own pace. However, perceived benefits were limited for oral production and listening comprehension, which can be attributed to the exclusively written mode of interaction.

Regarding the potential of AI-based tasks to complement textbook-based instruction, the findings suggest that ChatGPT activities can effectively extend classroom learning into out-of-class practice. By embedding tasks in familiar textbook scenarios, learners were able to recycle and apply previously introduced language in meaningful communicative contexts. The results also highlight the importance of structured pedagogical scaffolding, including guidance on prompt formulation and managing communication breakdowns. Task design should balance fluency-oriented interaction with accuracy-focused feedback to avoid disruption of communicative flow.

Overall, the results indicate that participants viewed the integration of AI into language learning positively and valued the opportunity to engage in interaction with AI systems. However, they also highlighted the need for structured linguistic and technical support to ensure effective use. Harnessing the benefits of AI technologies for L2 learning therefore depends on careful pedagogical framing and learner preparation.

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EVOLVE2CARE TRAINING SERIES: BUILDING CAPACITY FOR INNOVATORS AND LIVING LABS

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Abstract

The Evolve2Care Training Program Series was created to address a critical challenge: many promising ideas and technologies emerge in research settings, yet few reach real-world use. Transforming concepts into concrete solutions requires coordinated work among researchers, entrepreneurs, companies, investors, and support organisations. These interactions are often fragmented, slowing the transition from experimentation to implementation. To bridge this gap, Evolve2Care provides two coordinated six-part training programs: the Training for Innovators and the Training for Living Labs.

Keywords: *Training program, living labs, rapid prototyping, healthtech innovation, user-centred design.*

1. Introduction

Despite significant investments in research and innovation, the pathway from early-stage ideas to real-world health solutions remains complex and uncertain. Healthtech innovation often requires not only technological excellence, but also a deep understanding of users' needs, regulatory frameworks, market dynamics, and real-life implementation environments. Many promising initiatives struggle at this intersection, where technical development must align with practical, organisational, and societal constraints.

Living Labs play a crucial role in addressing this challenge by providing real-life experimentation settings that connect innovators with users, healthcare professionals, and public and private stakeholders. However, effective collaboration within these ecosystems requires shared skills, methodologies, and a common understanding of innovation processes. Innovators and Living Labs often face different, but complementary, capacity gaps that can limit the impact of their collaboration.

In this context, the Evolve2Care Training Program Series was designed to strengthen the capabilities of both Innovators and Living Labs, supporting them throughout the innovation journey, from early experimentation and rapid prototyping to user-centred validation and readiness for implementation. By offering two structured and coordinated training pathways, the programme aims to foster more effective collaboration and accelerate the translation of healthtech innovations into practice.

The Training for Innovators, led by Anthology Ventures, equips participants with a full innovation toolkit, including design thinking, challenge framing, rapid prototyping, user-centred testing, IP strategy, business modelling, and investor preparedness. Beyond live sessions, the program generated practical outputs: (i) a no-code chatbot template linked to a customizable Google Sheet for user feedback; and (ii) a Product Requirements Document and use-case prototype on hospital discharge management, created with structured prompts and the Lovable tool.

In parallel, the Training for Living Labs, led by the European Network of Living Labs (ENoLL), strengthens the capacity of Living Labs to facilitate a smoother transition from research to market-ready solutions. Building on gaps identified by ENoLL as part of their collaboration with its Members, and as identified in the booklet *Living Lab origins, developments, and future perspectives*, participants received practical tools including: (i) a service design blueprint for structuring user validation processes; and (ii) an ethics checklist to guide research and experimentation with end users.

This dual-track approach is a distinctive strength of Evolve2Care: innovators and Living Labs are trained through aligned frameworks that reinforce each other, creating a coherent innovation pathway. All outputs, including tools and resources, can be continuously accessed, and participation tracked via the ENoLL Living Labbers Academy, promoting ongoing learning and providing reusable materials to support future health-tech innovation projects.

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2. Methods

The dual-track training program aimed to strengthen both innovators' and Living Labs' capacity to develop, test, and implement health-tech solutions. Participants included researchers, early-stage entrepreneurs, and Living Lab professionals with diverse levels of experience, which shaped a progressive learning design starting from foundational concepts to applied skills. Innovators were guided through design thinking, rapid prototyping, business modelling, and commercialization strategies, while Living Labs focused on user validation, operational methodologies, stakeholder engagement, and ethical considerations. The two tracks were deliberately aligned to promote collaboration and ensure that skills and outputs complemented each other.

Both the Training Programs were developed using a **learner-centred pedagogical approach**, ensuring that content, activities, and materials respond directly to the needs and realities of the Living Labs and Innovators operating within the healthcare and transitional care sectors. The design intentionally combines *solid theoretical foundations* with *structured opportunities for practical application*, enabling participants not only to understand key concepts but also to translate them effectively into their operational environments. To support this, each module was structured around a **progressive learning pathway**, beginning with conceptual grounding and moving towards increasingly applied and reflective exercises.

All training sessions and materials were subsequently made freely available through ENoLL's Living Labbers Academy - https://academy.enoll.org/ , providing ongoing access to the content and enabling participants to revisit lessons, apply resources in their projects, and continue learning beyond the live sessions.

Figure 1. Training Series Web Banners.

3. Discussion and results

The EVOLVE2CARE dual-track training received highly positive feedback from participants across both tracks. Overall session quality was rated between 3 and 5 out of 5, with most detailed criteria content relevance, speaker quality, actionable tools, pacing, and resources scoring between 4 and 5.

Participants highlighted the relevance and practicality of the sessions. Innovators particularly appreciated guidance on design thinking, rapid prototyping, business modelling, and early-stage commercialization, while Living Lab participants valued learning about operational methodologies, user validation, and stakeholder engagement. The structured progression from foundational concepts to applied exercises, together with supporting materials such as slides and recordings, helped participants build confidence in applying their skills. Many reported that the training clarified their next steps in innovation and encouraged them to take concrete actions toward developing and validating `solutions.

In terms of impact, 43% of participants are already taking action, 29% plan to do so within 3-6 months, and 28% indicated they need further guidance. Feedback also showed strong interest in continued engagement with EVOLVE2CARE, suggesting the programme not only supported immediate learning but also strengthened ongoing collaboration and professional growth.

4. Conclusions

The EVOLVE2CARE dual-track training successfully empowered participants to take concrete action, with 43% already applying what they learned and most others planning next steps within the coming three to six months. Participants gained practical, actionable tools spanning design thinking, rapid prototyping, stakeholder engagement, and early-stage commercialization. The structured programme, supported by high-quality resources and expert guidance, boosted confidence, clarified next steps, and helped transform learning into immediate impact. Feedback also highlighted strong interest in continued engagement, demonstrating that the training not only achieved short-term results but also fostered long-term collaboration and professional growth.

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VIRTUAL PRESENTATIONS

FROM TRANSPARENCY TO ACCOUNTABILITY: A FRAMEWORK FOR ETHICAL AND EMPOWERING USE OF GENERATIVE AI IN HIGHER EDUCATION

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Abstract

The integration of Generative Artificial Intelligence in higher education marks a pivotal moment in redefining academic practice. While early responses often focused on restriction and detection, emerging evidence suggests that empowering educators and learners through ethical frameworks yields more sustainable and reflective engagement. This paper presents a five-part pedagogical framework, Transparency, Human–AI Collaboration, Contextualised AI Literacy, Institutional Responsibility, and Accountability-Based Assessment, designed to guide responsible GenAI adoption in teaching, learning, and research. Drawing on pre- and post-workshop survey data collected from academic staff at the University of Malta, the study examines shifts in educators' attitudes, confidence, and ethical reasoning following structured GenAI literacy interventions. Findings reveal significant increases in reflective use, transparency in disclosure, and openness to assessment reform when supported by clear institutional guidance. Two new recommendations, Reflective Transparency and Accountability Over Avoidance, extend the framework to emphasise that learners should be evaluated not for AI use itself, but for their capacity to justify, verify, and critically engage with it. The paper argues that the future of higher education lies in moving from prohibition to participation, from automation to co-agency, and from compliance to ethical creativity. By embedding these five guidelines into curricula and policy, institutions can transform GenAI from a disruptive challenge into an instrument of empowerment, scholarship, and integrity.

Keywords: *Generative AI, academic integrity, ethical pedagogy, assessment reform, AI literacy.*

1. Introduction

The rapid diffusion of Generative Artificial Intelligence (GenAI) tools, such as ChatGPT, Claude, and Google Gemini, into higher education has precipitated a profound shift in academic workflows, particularly in research, writing, teaching, and assessment. Unlike earlier forms of educational AI that focused on adaptation, analytics, or prediction, GenAI systems are capable of generating fluent text, explanations, feedback, and multimodal artefacts that closely resemble human-authored academic work. This qualitative shift has intensified longstanding questions around authorship, epistemic agency, and the role of the human scholar in AI-mediated learning environments (Zawacki-Richter et al., 2019; Knox, 2020; Miao & Holmes, 2023). In response to this rapid technological uptake, many higher education institutions have adopted precautionary or defensive strategies. Early institutional reactions have been characterised by bans on GenAI use, reliance on automated detection tools, and policy discourse framed primarily around academic misconduct and plagiarism (Cotton et al., 2023; Luo, 2024). While such responses are understandable in the face of uncertainty, they risk conflating ethical concerns with technological determinism and may inadvertently discourage transparency, reflection, and responsible engagement. Empirical and conceptual work increasingly suggests that detection-oriented approaches are fragile, inequitable, and pedagogically misaligned, particularly given the documented ease with which GenAI outputs can bypass detection systems (Perkins et al., 2024). A growing body of human-centred AI scholarship argues that GenAI should instead be framed as a pedagogical partner rather than a substitute for human cognition or judgement. From this perspective, the educational value of GenAI does not reside in automation or efficiency alone, but in its capacity to scaffold reflection, critique, and dialogic engagement when embedded within intentional pedagogical design (Biesta, 2020; Cope & Kalantzis, 2017; Montebello, 2020). Recent work has emphasised the importance of human-in-the-loop approaches, where educators retain epistemic authority and learners are supported to critically interrogate, refine, and justify AI-generated outputs rather than passively consume them. Despite this emerging consensus, there remains

a notable gap in the literature: a lack of integrated, practice-oriented frameworks that move beyond principles and policies to offer concrete guidance for educators and institutions. In particular, limited attention has been paid to how transparency, accountability, AI literacy, and assessment design can be aligned to empower learners without penalising responsible technology use. Much of the existing guidance focuses on acceptable use and disclosure, but offers little insight into how learning, authorship, and assessment validity can be preserved when cognitive engagement is no longer structurally enforced by traditional assessment mechanisms. This paper addresses this gap by proposing and empirically grounding a five-part framework for the ethical and empowering use of GenAI in higher education. The framework comprises: (1) Transparency in use, (2) Human–AI collaboration, (3) Contextualised AI literacy, (4) Institutional responsibility, and (5) Accountability-based assessment. The framework is informed by pre- and post-workshop survey data collected from academic staff participating in GenAI professional development initiatives at the University of Malta, complemented by qualitative reflections emerging from these engagements. The findings provide evidence of a shift from fear-based avoidance toward reflective, accountable, and pedagogically meaningful GenAI adoption when educators are supported by clear ethical guidance and assessment-aligned practices.

The remainder of this paper is structured as follows. Section 2 situates the study within relevant theoretical and pedagogical traditions, including constructivist learning, human-centred AI, and assessment-for-learning. Section 3 outlines the methodological design of the GenAI workshops and survey instruments. Section 4 presents and discusses the empirical findings. Section 5 elaborates the proposed five-part framework, with illustrative examples drawn from practice. The paper concludes by discussing implications for educators, institutions, and policy makers seeking to move from avoidance to accountability in the age of Generative AI.

2. Theoretical and pedagogical background

The integration of GenAI into higher education represents not merely a technological development, but a pedagogical and epistemic transformation. Unlike earlier Artificial Intelligence in Education (AIED) systems, GenAI actively participates in meaning-making through language generation, explanation, and feedback, reshaping how academic knowledge is produced, evaluated, and legitimised (Montebello, 2025a). Constructivist and sociocultural learning theories provide a critical lens through which to interpret this transformation. Learning is conceptualised as an active process of interpretation and sense-making rather than passive content acquisition (Cope & Kalantzis, 2017). Biesta's (2020) notion of world-centred education further emphasises judgement, responsibility, and subjectivity as central educational outcomes, privileging human engagement over performative efficiency. Within these traditions, assessment functions as a mechanism for eliciting cognitive engagement and reflective judgement. GenAI disrupts this alignment by enabling learners to produce academically acceptable artefacts without necessarily engaging in the cognitive processes traditionally associated with learning (Montebello, 2025b). This decoupling shifts engagement from cognitive necessity to cognitive choice, a structural consequence of technological affordances rather than learner misconduct. Human-centred approaches respond by reasserting human agency through educator-in-the-loop design, transparency, and accountability, positioning AI outputs as objects of critique rather than proxies for thinking. Assessment theory reinforces this position. Assessment-for-learning scholarship emphasises process, feedback, and metacognition over product (Black & Wiliam, 1998; Nicol & Macfarlane-Dick, 2006). However, many contemporary assessment practices remain artefact-focused and thus vulnerable to unreflective GenAI use. Dialogic and oral assessment approaches offer more resilient alternatives by foregrounding explanation, justification, and interaction. Policy guidance from UNESCO and the European Union increasingly reflects these concerns, emphasising transparency, ethical literacy, and human oversight (European Commission, 2024; Miao & Holmes, 2023). Nevertheless, such guidance often lacks pedagogically actionable models. This paper builds on human-centred AI, constructivist pedagogy, and assessment theory to address this gap through an integrated, practice-grounded framework.

3. Methodology

This study adopts a practice-based, interpretivist research design to examine how structured pedagogical interventions can support ethical and empowering use of Generative Artificial Intelligence in higher education. Rather than treating GenAI adoption as a purely technical or behavioural phenomenon, the methodology is grounded in the assumption that educators' beliefs, confidence, and pedagogical intent play a decisive role in shaping how AI is integrated into teaching, learning, and assessment. This approach aligns with human-centred AI scholarship, which emphasises situated practice, reflexivity, and educator agency as core dimensions of responsible GenAI use in education. The study was conducted at the

University of Malta between 2024 and 2025 as part of a series of professional development workshops focused on GenAI in teaching, research, and assessment. Participants comprised academic staff from a wide range of disciplines, including the arts and humanities, social sciences, life sciences, physical sciences, and technology-related fields. This disciplinary diversity was intentional, reflecting the premise that GenAI literacy and ethical use must be contextualised rather than treated as a generic skill. Participation was voluntary, and workshops were advertised institutionally as exploratory and developmental rather than evaluative. This framing was critical in fostering openness, reducing fear of surveillance, and encouraging honest engagement with ethical concerns around GenAI use. Each workshop followed a structured yet flexible design informed by constructivist and inquiry-based pedagogy. Sessions typically combined conceptual grounding in human-centred GenAI principles, including transparency, educator-in-the-loop design, and learner agency. Hands-on engagement with GenAI tools (Gemini, ChatGPT, Claude) was an integral part of every session, applied to authentic academic tasks such as literature synthesis, feedback generation, assessment redesign, and reflective writing. This was followed by a guided discussion and reflection on ethical implications, authorship, assessment validity, and institutional responsibility. Rather than prescribing 'correct' uses of GenAI, the workshops deliberately foregrounded critical interrogation of AI outputs, comparative prompting, and justification of decisions. This design choice aligns with prior work emphasising that GenAI should function as a pedagogical partner rather than an outsourcing mechanism for cognition or judgement. Data were collected using a pre- and post-workshop survey design, complemented by qualitative reflections generated during and after workshop activities. The pre-workshop survey captured baseline attitudes toward GenAI, including levels of confidence, perceived risks, ethical concerns, and beliefs about assessment and academic integrity. The post-workshop survey repeated core items while also probing changes in perception, perceived pedagogical value, and willingness to adopt transparent and accountable GenAI practices. Survey instruments employed Likert-scale items and open-ended questions to capture both measurable shifts and nuanced reflections. Particular attention was paid to attitudes toward transparency, disclosure of AI use, and assessment fairness, areas that later informed the development of the accountability-based recommendations. In addition, anonymised qualitative data were drawn from reflective prompts, group discussions, and written comments produced during workshop activities. These reflections provided insight into how educators reasoned about GenAI use, how tensions between innovation and integrity were negotiated, and how assessment practices were reimagined in light of AI capabilities. Quantitative survey data were analysed descriptively to identify pre–post shifts in confidence, ethical awareness, and pedagogical orientation. Qualitative data were analysed thematically using an inductive approach, focusing on recurring patterns related to transparency, agency, assessment design, and institutional responsibility. These themes were then mapped against existing human-centred GenAI principles and assessment theory to inform the development of the five-part framework. Importantly, the purpose of the analysis was not to generalise statistically, but to empirically ground a pedagogical framework in authentic academic practice. In this sense, the methodology serves as a bridge between theory and application, providing evidence that ethical and empowering GenAI integration is both pedagogically feasible and professionally transformative when supported by intentional design.

4. Findings and discussion

Analysis of the pre- and post-workshop survey data, supported by qualitative reflections, reveals a consistent shift in how academic staff conceptualised Generative AI in relation to teaching, learning, and assessment. Prior to the workshops, participants commonly expressed uncertainty and concern, particularly around academic integrity, assessment validity, and the perceived loss of control over authorship. GenAI was frequently framed as a disruptive or risky technology, with several respondents indicating that avoidance or restriction appeared to be the safest institutional response. Post-workshop data, however, indicates a marked change in orientation. Participants reported increased confidence in engaging with GenAI, greater clarity regarding ethical use, and stronger alignment between GenAI practices and pedagogical intent. Rather than viewing GenAI primarily as a threat, many academics began to frame it as a pedagogical resource—provided its use was transparent, contextualised, and accountable. This shift supports existing human-centred GenAI research, which emphasises that educator confidence and ethical literacy are prerequisites for responsible integration. A dominant qualitative theme concerned transparency. Participants consistently reported that structured discussion of AI disclosure reduced anxiety and reframed transparency as a scholarly practice rather than a confession of misconduct. Several academics noted that once transparency was normalised, conversations could move beyond detection toward learning design and assessment quality. This finding aligns with broader critiques of surveillance-driven integrity models and supports the argument that openness fosters ethical engagement more effectively than prohibition. A second theme related to assessment and accountability. Initially, many participants assumed that GenAI use would

inevitably undermine assessment fairness. Following the workshops, however, there was growing agreement that students should not be penalised for GenAI use per se, but rather evaluated on their ability to justify, explain, and critically engage with AI-assisted outputs. This reframing reflects a broader pedagogical shift from product-oriented assessment toward process-oriented and dialogic forms of evaluation, including reflective and oral assessment practices. Participants also highlighted the importance of contextualised AI literacy, noting that ethical use cannot be meaningfully taught in abstraction from disciplinary norms and assessment practices. Generic AI policies were widely perceived as insufficient without concrete pedagogical models that educators could adapt to their own contexts. Taken together, the findings suggest that ethical GenAI integration is less a technical problem than a pedagogical one. When educators are supported through structured professional development, reflective dialogue, and principled frameworks, fear-based responses give way to intentional, accountable practice. These findings empirically ground the five-part framework presented in the next section, positioning it as a response not only to technological change, but to the evolving educational responsibilities of educators and institutions in AI-mediated environments.

5. A five-part framework for ethical and empowering GenAI integration

Building on the theoretical foundations outlined in Section 2 and the empirical findings presented in Section 4, this section introduces a five-part framework designed to support the ethical and empowering integration of Generative Artificial Intelligence in higher education. The framework is intentionally pedagogical rather than prescriptive, offering design principles that educators and institutions can adapt to their specific disciplinary, institutional, and assessment contexts. Its central premise is that ethical GenAI use is best achieved through transparency, accountability, and intentional learning design rather than restriction or surveillance. Transparency constitutes the foundational principle of the framework. Rather than treating disclosure of GenAI use as an admission of misconduct, transparency is reframed as a scholarly practice aligned with academic reflexivity and methodological integrity. Educators and learners are encouraged to explicitly acknowledge where, how, and why GenAI tools have been used in the production of academic work. Findings from the workshops indicate that transparent disclosure reduces anxiety and fosters trust when decoupled from punitive consequences. Participants reported that reflective AI-use statements enabled more productive discussions about authorship, epistemic contribution, and learning processes. This aligns with human-centred GenAI principles that position transparency and explainability as pedagogical affordances rather than compliance mechanisms. In practice, transparency can be operationalised through short AI-use declarations, reflective appendices, or methodological statements that mirror existing academic conventions such as ethics disclosures. The second guideline emphasises that GenAI should augment rather than replace human cognition and judgement. Learners remain epistemically responsible for interpreting, validating, and contextualising AI-generated outputs. GenAI is positioned as a dialogic partner that can support idea generation, surface alternative perspectives, and challenge assumptions, but not as a substitute for scholarly reasoning. Workshop participants highlighted the pedagogical value of comparative prompting, critical interrogation of AI responses, and iterative refinement of outputs. These practices reinforce the role of the learner as an active decision-maker and align with educator-in-the-loop design approaches that prevent over-reliance on automation. Importantly, this guideline reinforces that responsibility does not diminish with tool use, rather, GenAI increases the need for human judgement, particularly in contexts requiring nuance, interpretation, and ethical reasoning. The third guideline recognises that GenAI literacy cannot be meaningfully taught as a generic or decontextualised skill. Ethical and effective GenAI use is inherently discipline-specific, shaped by epistemic norms, assessment practices, and professional expectations. What constitutes responsible AI use in creative writing, legal reasoning, scientific reporting, or data analysis varies considerably. Participants consistently rejected one-size-fits-all AI policies, noting that ethical engagement requires contextual understanding. Contextualised AI literacy therefore involves embedding critical engagement with GenAI within disciplinary curricula, assessment tasks, and scholarly practices. Educators play a crucial role in modelling discipline-appropriate GenAI use and in making evaluative criteria explicit. This approach aligns with constructivist pedagogy and human-centred AI design, both of which emphasise situated judgement over procedural compliance. The fourth guideline shifts attention from individual behaviour to institutional responsibility. Ethical GenAI integration cannot be sustained through individual effort alone, it requires coherent institutional frameworks that align policy, pedagogy, assessment, and professional development. Workshop findings revealed strong demand for institutional clarity, not in the form of restrictive rules, but through shared principles, exemplars, and pedagogical support. Without such alignment, transparent and innovative GenAI practices remain uneven and risky. Institutions therefore have a responsibility to legitimise ethical GenAI use, provide professional development opportunities, and ensure that policies support accountability rather than fear-based compliance. The final guideline addresses

assessment directly and represents a critical extension of the framework. Rather than penalising GenAI use, assessment should prioritise accountability, justification, and cognitive engagement. Participants increasingly converged on the view that students should not be marked down for using GenAI, provided they can explain, defend, and critically reflect on their work. Accountability-based assessment shifts the evaluative focus from whether GenAI was used to how it was used. Practical strategies include reflective commentaries, annotated submissions, oral explanations, and transparency statements that make student reasoning visible. Such approaches restore alignment between learning and assessment while remaining compatible with responsible GenAI use. This guideline reinforces that academic integrity in AI-mediated contexts is demonstrated through accountable engagement rather than tool avoidance. Together, these five guidelines form an integrated framework that moves higher education from avoidance to accountability, from detection to design, and from automation to agency. They reassert that ethical GenAI integration is achieved not by restricting tools, but by cultivating transparent, reflective, and accountable scholarly practice grounded in human judgement and pedagogical intent.

6. Implications, recommendations, and conclusion

The framework proposed in this paper demonstrates that the challenges posed by GenAI in higher education are primarily pedagogical and organisational rather than technical. Restrictive and detection-driven responses risk undermining transparency, trust, and learning, whereas accountability-based approaches foreground reflection, agency, and educational integrity. For educators, this entails a shift toward modelling transparent GenAI use and designing learning tasks that require justification, critique, and reflective engagement. Assessment practices must evolve from product-oriented evaluation to process-focused accountability. Institutions play a critical role by aligning policy, pedagogy, and professional development around human-centred principles that legitimise ethical GenAI use. In conclusion, academic integrity in the age of GenAI is best preserved through accountability rather than avoidance. By integrating transparency, contextualised AI literacy, and assessment redesign, GenAI can be repositioned as a catalyst for pedagogical renewal rather than a threat to scholarly values.

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MODELS OF INTERACTION BETWEEN LIBRARY EDUCATION AND LIBRARY RESOURCES IN THE CONTEXT OF DIGITAL TRANSFORMATION

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Abstract

This report examines the theoretical and applied aspects of the interaction between library education and library resources in the context of contemporary digital transformation. It analyzes the main models through which digital technologies change the structure, content, and methodology of library science education, as well as the ways students and faculty use library resources in the learning process. The study emphasizes the role of digital platforms, electronic catalogs, virtual libraries, and open educational resources as tools for modernizing teaching practices and promoting information literacy. Examples of successful integration models are presented, achieving synergy between academic teaching, scientific knowledge, and access to digital resources. In conclusion, it underscores the importance of the strategic use of digital technologies for developing competencies related to critical thinking, information management, and professional adaptability in the library environment. The report offers an analytical perspective on opportunities for sustainable development of library education through effective interaction with digital library resources.

Keywords: *Library education, digital transformation, library resources, information literacy, open educational resources.*

1. Introduction

Library education stands at the crossroads of traditional knowledge and the digital revolution, where interaction with library resources transforms from a static process into a dynamic, interactive ecosystem supporting innovation and adaptability. Digital transformation—defined as the comprehensive integration of digital technologies into business processes, culture, and values—fundamentally changes librarianship, creating new models of interaction between education and resources, where the traditional roles of librarians evolve from passive custodians to active digital curators, data analysts, and knowledge facilitators. This process is accelerated by global trends such as the exponential growth of big data (an average of 2.5 quintillion bytes daily), the proliferation of AI and machine learning, cloud platforms (AWS, Azure, Google Cloud for library applications), and open data initiatives (Linked Open Data, Wikidata), which require future specialists not only technical skills but also strategic thinking for information management in a networked environment.

In the context of the rapid development of AI (recommendation engines like those in LibGuides, generative AI for metadata generation), cloud technologies, and open data, library education must adapt to a dynamic environment where students are not just consumers but creators of information through tools like OER Commons, Zenodo, and collaborative platforms (Hypothes.is for annotations). This report aims to analyze key integration models—integrated platforms (LMS-ILS API integration), OER collaborations, and AI personalization—while emphasizing the role of digital resources in enhancing competencies according to IFLA standards and national frameworks such as those of the Ministry of Culture. This is particularly relevant for Bulgaria, where institutions like Sofia University "St. Kliment Ohridski," the National Library "St. St. Cyril and Methodius" (NLCM), and the Bulgarian Academy of Sciences (BAS) lead digital initiatives but face challenges like the digital divide (20% of the population without stable internet) and the need for standardization per BDS ISO 690:2021.

Objectives of the report:

1. Identification and comparative analysis of main models through theoretical and empirical data;
2. Detailed review of practical examples from Bulgaria (national projects) and the world (IFLA, JISC, British Library);
3. Formulation of specific proposals for sustainable development with a focus on the Bulgarian context, including pilot projects and KPI monitoring.

The methodology includes a systematic literature review (IFLA Trend Reports 2024–2025), case studies, and a comparative table to ensure practical applicability for academic and institutional stakeholders.

Table 1.

Stage	Main Focus Points	Technologies	Examples in Bulgaria
Traditional (pre-1990)	AACR2 cataloging, reference	Cards, Dewey	Classical SU programs
Digital (1990–2010)	OPAC, electronic databases	MARC, Z39.50	First OPAC at NLCM
Web 2.0 (2010–2020)	User-generated, social tools	Blogs, wikis, LibGuides	Europeana integration
AI-driven (2020+)	Personalization, predictive analytics	ML, NLP, chatbots	AI in UNIBIT projects

2. Theoretical foundations of interaction

The theoretical foundations of the interaction between library education and library resources in the context of digital transformation are rooted in the evolution of information sciences from librarianship to digital knowledge management, where learning models shift from linear (lecture-notes-book) to networked and personalized (data-driven learning ecosystems). This transformation is based on key paradigms such as constructivism (students construct knowledge through interaction with resources), connectivism (George Siemens, 2005—learning through networks), and the ACRL framework for information literacy, expanded with digital competencies (data curation, AI literacy) according to IFLA Guidelines. In the digital context, interaction is modeled through systems theory, where library resources act as input (data, OER), education as process (curation, analysis), and competencies as output (adaptive specialists).

2.1. Evolution of library education

The evolution of library education reflects technological changes in society, passing through four main stages: traditional (pre-1990—focus on physical catalogs and reference), digital (1990–2010—introduction of OPAC and electronic databases), Web 2.0 (2010–2020—social media, user-generated content), and AI-driven (2020+—personalization, predictive analytics). Traditional education focused on cataloguing per AACR2/RDA standards, reference services, and physical collection management, but the digital era introduced modern models like "hybrid learning" (blended learning—combination of online and in-person sessions), "flipped classroom" (self-study of resources beforehand), and "gamification" (badges and gamified modules for data literacy via platforms like Kahoot or Duolingo-style library apps). Electronic catalogs (WorldCat, Deutsche Nationalbibliothek—DNB, national OPAC like NLCM's) integrate with curricula for real search simulations, metadata generation with tools like MARCEdit, and semantic search via RDF/SPARQL.

According to IFLA Trend Reports (2023–2025), 70% of global library programs include mandatory modules on digital literacy (information literacy), data literacy (big data management), AI ethics (bias detection in algorithms), sustainable information practices (green data centers for libraries), and inclusivity (AI-powered accessibility tools like OCR for the visually impaired via Google Read&Write). These programs emphasize new roles: digital librarian (OER curator), data steward (FAIR data), knowledge broker (insight creator from data), and innovation manager (AI pilot projects). In Bulgaria, bachelor's and master's programs at Sofia University "St. Kliment Ohridski," New Bulgarian University (NBU), UNIBIT, and BAS include BDS ISO 690:2021 for digital citations, modules on Linked Open Data (LOD for Bulgarian heritage), national digitization initiatives (NLCM's "Chernorizets Hrabar" project), and partnerships with Europeana for metadata enrichment. The challenge is the transition to competency-based education (CBE), where students demonstrate skills through portfolios with real projects (e.g., creating an institutional repository in DSpace) rather than exams.

2.2. Role of digital resources

Digital resources represent the main catalyst for transforming library education, turning them from static archives into dynamic, interactive platforms for learning and collaboration. They are classified into three main categories: (1) virtual libraries and aggregators like Europeana (over 50 million objects from 4000+ institutions), HathiTrust (17 million scanned volumes), Digital Public Library of America (DPLA),

and Bulgaria's NLCM "Chernorizets Hrabar," providing access to massive digital collections with advanced search tools (faceted search, AI-powered relevance ranking) for practical exercises in metadata analysis and thematic curation; (2) open educational resources (OER) via platforms like UNESCO OER Commons (45,000+ materials), MERLOT (organized by discipline), OpenStax (free textbooks), and Zenodo (CERN repository for research data), allowing students to create, remix, and peer-review content within the 5R principles (Retain, Reuse, Revise, Remix, Redistribute), supporting open pedagogy and open science; (3) institutional repositories and tools like DSpace, EPrints, Islandora (Fedora-based), supporting storage, dissemination, and metadata management per standards like Dublin Core, MARCXML, BIBFRAME, and OAI-PMH protocols for harvesting.

These resources serve as a bridge between theory and practice through real-time simulations: searching with Boolean operators and semantic tools (SPARQL for RDF), data curation with OpenRefine, collaborative annotation via Hypothes.is, data visualization with Tableau Public, Voyant Tools, or Google Data Studio. They support information literacy development through established frameworks: ACRL Framework (six frames—Authority is Constructed, Information Creation as Process, etc.), IFLA Guidelines for Information Literacy, and Bulgarian BDS ISO 690:2021 for citing digital sources. In the digital transformation context, resources facilitate datafication (turning information into analyzable data via ETL processes), FAIR principles (Findable, Accessible, Interoperable, Reusable for open science), and Linked Open Data (LOD) initiatives, where students work with ontologies like schema.org and Wikidata for semantic enrichment.

Table 2.

Category	**Examples**	**Functions in Education**	**Standards**
Virtual libraries	Europeana, HathiTrust, NLCM	Search, curation	OAI-PMH, API
OER platforms	OER Commons, Zenodo	Remix, peer-review	5R principles, CC licenses
Repositories	DSpace, EPrints	Metadata, harvesting	Dublin Core, BIBFRAME

In the Bulgarian context, resources like NLCM's electronic catalog, BAS digital collections, and Europeana integration enable practical projects: creating virtual exhibitions, BIBFRAME metadata migration, and OER modules for master's courses. Advantages include scalability (cloud CDN for global access), personalization (AI tagging), and sustainability (digital preservation with PREMIS standards), but they require training on tools like MARCEdit, RDF editors, and API clients (Postman for OAI-PMH).

3. Main models of interaction

The main models of interaction represent practical applications of theoretical foundations, classified by degree of technological integration and pedagogical orientation. They enable systemic links between learning platforms (LMS), library systems (ILS), and user needs, achieving synergy through APIs, machine learning, and open standards. The analyzed models have been empirically tested in global and Bulgarian contexts, with measured results on KPIs like search efficiency, user satisfaction, and competency development.

3.1. Integrated platform model

This model represents the primary architectural approach for seamless integration, where learning platforms (Moodle, Blackboard, Canvas LMS) connect directly to library integrated systems (ILS: Koha OSS, Ex Libris Alma, FOLIO open source) via RESTful APIs, LTI (Learning Tools Interoperability) standards, and single sign-on (SAML/Shibboleth). Key features include real-time resource discovery (EDUCAUSE "discovery layer"), embedded librarianship (librarians in LMS courses), and analytics dashboards for usage tracking (Google Analytics, Matomo). Advantages: reduction in context switching by 60%, increase in resource utilization by 40%. Example from Bulgaria: Sofia University "St. Kliment Ohridski" University Library implements an integrated catalog via API link between Moodle and Koha, used in library science student projects. Results: efficiency +40%, search time -25% via automated metadata and federated search. International: Harvard Library's Alma-Moodle integration with AI facets.

3.2. Open resources and collaboration model

Focused on open pedagogy, this model uses OER platforms (UNESCO OER Commons, MERLOT, Hypothes.is) for creating, remixing, and peer-reviewing content per 5R principles, integrating institutional repositories (DSpace, Zenodo) with LMS via LTI and OAI-PMH harvesting. Students become co-creators through collaborative editing (Google Workspace, Etherpad), wiki-based courses, and open badges (Badgr). Advantages: democratization of knowledge, 100% reduction in material fees, peer learning +30%. In Bulgaria: NLCM's "Digital Library" project integrates OER into master's programs at SU and NBU, with peer-review via Zenodo and BAS-university collaboration for heritage digitization. Students create virtual exhibitions, cited per BDS ISO 690:2021. International: MIT OpenCourseWare + OERu network.

3.3. AI-based personalized model

The most innovative model uses AI/ML for adaptive learning: recommendation engines (collaborative filtering in LibGuides, Amazon Personalize), NLP chatbots (RASA, IBM Watson Assistant), predictive analytics for resource allocation. It integrates via microservices architecture with LMS plugins (H5P AI content). Advantages: personalization +35% engagement, pro-active reference services. Example: British Library's "Living with machines" AI discovery tool analyzes user behavior for personalized guides; JISC models improve literacy by 35%. In Bulgaria: Pilot AI chatbots at NBU for bibliographic assistance, integrated with OPAC.

4. Conclusion

Digital transformation is not merely a technological process but a strategic paradigm that rethinks library education as a dynamic ecosystem integrating resources, knowledge, and human capital for sustainable development in the information society. The analyzed models—integrated platforms, OER collaborations, and AI personalization—demonstrate that effective interaction between education and digital resources not only enhances operational efficiency (up to 40% per Bulgarian examples) but also develops key competencies like critical thinking, data literacy, and ethical AI use, preparing future librarians for roles as digital stewards and knowledge curators in the era of big data and Web 3.0.

In the Bulgarian context, where institutions like Sofia University "St. Kliment Ohridski," NLCM, and BAS lead digital initiatives, this synergy is particularly important for overcoming challenges like the digital divide, GDPR compliance, and limited resources, while creating models for regional leadership in Southeast Europe through partnerships with Europeana and IFLA. Long-term, strategic use of technologies like blockchain for preservation, VR/AR for immersive learning, and predictive analytics for resource allocation will ensure not only adaptability but also innovative contributions to global sustainable development goals (SDGs 4 and 9), turning libraries into catalysts for inclusive knowledge.

Recommendations for Action:

- Short-term: Implement mandatory AI and data literacy modules in curricula with BDS ISO 690:2021 certification.
- Medium-term: Develop national pilot projects for LMS-ILS API integration, focusing on OER from NLCM and BAS.
- Long-term: Establish interdisciplinary centers for digital library education with UNESCO/IFLA partnerships and investments in AI and blockchain infrastructure.
- Monitoring: Regular efficiency assessments via KPIs (usage stats, student outcomes) and updates per IFLA Trend Reports.

This approach ensures not only operational modernization but also strategic positioning of Bulgarian librarianship in the global digital landscape.

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EMOTIONAL RELEASE IN DIGITAL LEARNING SPACES: INTEGRATING SEDONA-INSPIRED PRACTICES INTO ELEARNING PLATFORMS FOR STUDENT WELL-BEING

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Abstract

The proliferation of online education post-COVID-19 has amplified emotional challenges such as anxiety and isolation among learners, necessitating innovative interventions to enhance well-being in digital spaces. This paper proposes an exploratory model for integrating Sedona-inspired emotional release techniques—focusing on awareness, acceptance, and letting go—into eLearning platforms like Moodle, with adaptable low-tech and high-tech (e.g., VR/AR) modules to foster resilience without disrupting academic workflows. Grounded in established theories including Gross's Process Model of Emotion Regulation, Pekrun's Control-Value Theory, and Self-Determination Theory, the framework hypothesizes potential reductions in anxiety and improvements in engagement; however, confirmatory trials are essential, as current evidence remains exploratory. Drawing on a logic model of presumed mechanisms and preliminary data from a small-scale case study (n=15 online learners), the approach demonstrated an exploratory 25% mean reduction in State-Trait Anxiety Inventory scores (Hedges' g_rm=1.66, 95% CI [0.95, 2.37]), alongside 18% increased session engagement, though subject to selection bias and limited generalizability. The study outlines methodological rigor, including stratified randomization, mixed-effects modeling, fidelity monitoring, and CONSORT-EHEALTH compliance, while addressing ethical safeguards for psychological risks and data protection. By advocating scalable, inclusive tools, this work contributes to the discourse on holistic digital education, urging multi-site replications to validate its potential in diverse cultural contexts and bridge gaps in emotional support for remote learning.

Keywords: *eLearning, student well-being, emotion regulation, anxiety reduction, Sedona Method.*

1. Introduction

The post-pandemic era has solidified online and hybrid learning as a cornerstone of global education, with UNESCO reporting over 1.5 billion students affected by remote education during COVID-19. While eLearning offers flexibility and accessibility, it may exacerbate emotional challenges: isolation, screen fatigue, and "Zoom anxiety" could contribute to heightened stress levels, with studies indicating a potential 71% increase in student anxiety due to the outbreak. A meta-analysis of 18 studies during the pandemic revealed high prevalence rates of anxiety (up to 50% in some cohorts) among remote learners, linked to factors like disrupted social interactions and academic pressures.

This paper addresses this gap by proposing a digital adaptation of emotional release techniques inspired by the Sedona Method—a structured approach emphasizing awareness, acceptance, and letting go of negative emotions. Originally designed for in-person use, we reimagine it for eLearning platforms, creating interactive modules that may foster emotional resilience without disrupting academic flow. Building on experiential learning theory, our model integrates virtual tools to make emotional release potentially as seamless as a quiz or forum post, though empirical support for this specific adaptation is preliminary.

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The objective is twofold: (1) to outline a scalable framework for embedding Sedona-inspired practices in platforms like Moodle or Canvas; and (2) to synthesize empirical evidence from conceptually similar studies, supplemented by preliminary data from a small-scale case study, to explore potential impacts on student well-being. By bridging emotional intelligence with edtech, this work aligns with the conference's call for "new learning and teaching models" and "technology in teaching and learning," while acknowledging limitations in direct evidence for promoting inclusive, resilient digital education.

2. Literature review

2.1. Emotional challenges in elearning

Research suggests the emotional toll of digital education: a cross-sectional survey of university students in Brazil found 71% reporting increased anxiety during online learning, with stressors including health concerns and concentration difficulties. Similarly, a systematic review highlighted that positive achievement emotions (e.g., enjoyment) may enhance online engagement, while negative ones (e.g., anxiety) could reduce it. Post-pandemic, 40% of online learners report heightened anxiety due to asynchronous interactions and lack of non-verbal cues.

2.2. The Sedona Method: Core principles and adaptability

The Sedona Method, developed by Lester Levenson, involves three steps: (1) **Awareness** (identifying emotions); (2) **Acceptance** (non-judgmental acknowledgment); and (3) **Letting Go** (releasing via inquiry, e.g., "Could I let this go now?"). While direct RCTs on Sedona are scarce, with no recent trials identified in 2023-2025 specifically for emotional release in educational settings, conceptual similarities exist with other techniques, though efficacy claims are not transferred here. In education, prior work explored Sedona-inspired approaches in traditional classrooms, but digital adaptations remain exploratory.

2.3. Digital innovations in emotional education

Emerging edtech tools like AI-driven chatbots and VR for mindfulness offer precedents, with meta-analyses suggesting digital interventions may reduce stress and improve emotional regulation in exploratory contexts. Our model draws conceptual parallels to these, gamifying Sedona principles within integrated conceptual models for sustainable online learning, though without assuming shared efficacy. Gaps in literature: Few studies integrate release-based methods into scalable eLearning, particularly in non-Western contexts like Eastern Europe, where digital divides may amplify emotional inequities.

2.4. Theoretical anchoring and logic model

The model aligns with Gross's Process Model of Emotion Regulation, mapping awareness to attentional deployment, acceptance to cognitive change, and letting go to response modulation. It also connects to Pekrun's Control-Value Theory, where perceived control over digital tasks and value of emotional tools may influence achievement emotions like anxiety. Finally, Self-Determination Theory (SDT) by Ryan and Deci supports how modules could enhance autonomy (self-paced release), competence (mastering emotions), and relatedness (peer-sharing options).

Logic Model of Presumed Mechanisms

- Inputs: Sedona-inspired modules (awareness prompts, acceptance reflections, letting go exercises).
- Activities: Daily/weekly digital interactions (e.g., journaling, guided audio).
- Outputs: Increased self-reported emotional awareness; completed sessions.
- Short-term Outcomes: Potential reduction in state anxiety via cognitive reappraisal (per Gross).
- Long-term Outcomes: Exploratory improvements in engagement and well-being, mediated by perceived control (per Pekrun) and autonomy (per SDT).
- Assumptions: Participants engage honestly; no adverse effects from release.

3. Proposed model: Digital Sedona framework for elearning

We propose a modular framework adaptable to existing platforms, structured around Sedona's principles with digital enhancements. Low-tech alternatives (e.g., text-based journaling) are emphasized for feasibility in resource-limited settings, with VR/AR as optional enhancements.

3.1. Core components

1. Awareness Module: Interactive self-assessments (e.g., emoji-based emotion trackers) embedded in LMS dashboards. Students log pre-lecture emotions, triggering personalized nudges. (Low-tech alt: Text prompts.)
2. Acceptance Module: Guided audio/video prompts (5-10 min) using AI voiceovers, encouraging non-judgmental reflection via branching narratives. (Low-tech alt: Static audio files.)
3. Letting Go Module: VR/AR visualizations (e.g., "releasing" emotions as digital clouds) or text-based journaling with sentiment analysis feedback. (Low-tech alt: Guided text exercises.)

3.2. Integration strategy

- Platform Compatibility: Plugins for Moodle, Google Classroom, or Zoom extensions.
- Scalability: Asynchronous (self-paced) and synchronous (live sessions) options.
- Inclusivity: Multilingual support and accessibility features (e.g., text-to-speech for neurodiverse users).
- Assessment: Pre/post EI scales integrated via quizzes.

Table 1. Digital Sedona Framework Modules.

Module	Principle	Tool (Low-tech alternative)	Duration	Expected Outcome
Awareness	Emotion identification	Emotion slider + AI prompt (text)	2–3 min	Increased self-awareness
Acceptance	Non-judgmental acknowledgment	Guided video (audio)	5 min	Reduced emotional resistance
Letting Go	Emotional release	VR visualization + journaling (text)	7–10 min	Reduced stress and anxiety

3.3. Visual model: Digital Sedona framework

The proposed framework follows a sequential flow integrated into the eLearning environment:

1. Entry Point: Student accesses the eLearning platform
2. Awareness Module: Pre-lecture emotional check (slider or text prompt)
3. Conditional Trigger: If elevated anxiety is detected
4. Acceptance Module: Guided reflection (audio, video, or text-based)
5. Letting Go Module: Emotional release exercise (VR/AR or text journaling)
6. Post-Module Assessment: Brief emotional intelligence (EI) check and engagement tracking
7. Integration: Return to academic content with potentially reduced emotional load
8. Outcome: Improved well-being and learning experience

A feedback loop enables adaptive personalization through user data (e.g., emotion logs), while low-tech alternatives ensure accessibility across diverse contexts**.**

4. Methodology: Proposed pilot study design

This study adopts a pilot experimental design, aligned with established guidelines for digital health interventions and preregistered on the Open Science Framework (OSF). It aims to evaluate the effectiveness of Sedona-inspired modules integrated into an eLearning platform. Quantitative data will be analyzed using mixed-effects models to assess changes in anxiety and engagement over time.

4.1. Participants

The sample consists of 100 undergraduate students (aged 18–24) enrolled in a psychology program and participating in a hybrid course on emotional intelligence. Inclusion criteria include fluency in Romanian or English, access to stable internet, and moderate anxiety levels (STAI-Y scores 40–60). Exclusion criteria include severe self-reported mental health conditions and prior experience with similar emotional techniques. Participants are recruited through university announcements, with informed consent obtained prior to participation. Baseline measures include demographic variables and initial anxiety levels.

4.2. Intervention

Participants engage in a structured 8-week program consisting of 12 Sedona-inspired modules (three per week) delivered via a Moodle plugin and integrated into course activities. The control group follows a parallel schedule using neutral digital study skills modules. Basic adherence is monitored through module completion logs, and participant safety is ensured through weekly self-reported monitoring of emotional states, with referral procedures in place if significant distress is detected.

Participants are randomly assigned (1:1) to intervention or control groups using a stratified approach based on demographic and baseline characteristics. Strategies such as reminders and incentives are used to minimize dropout.

4.3. Data collection and analysis

Quantitative data are collected using pre- and post-intervention measures, including the State-Trait Anxiety Inventory (STAI-Y) and the Student Stress Inventory (SSI), alongside platform-based engagement metrics. Qualitative data are obtained through a subset of semi-structured interviews and reflective journals. Data are analyzed using mixed-effects models to examine changes over time, with appropriate handling of missing data and adjustments for multiple comparisons.

5. Preliminary data: Small-scale case study

To provide initial evidence, a preliminary case study was conducted with 15 volunteers from Enalogos Academy (aged 20-25, online learners; recruited via internal email list, self-selected with moderate anxiety screening—explicit bias: autoselection may inflate positive responses due to motivated participants). Using a simplified 4-week version of the modules (awareness via app trackers, acceptance via guided videos, letting go via journaling), pre/post STAI-Y scores showed a mean reduction of 25% (pre M=48.3, SD=7.2, 95% CI [44.3, 52.3]; post M=36.2, SD=6.5, 95% CI [32.6, 39.8]; $t(14)=3.45$, $p<0.01$). Measured pre-post correlation $r=0.62$ (from paired data); recalculated $g_{rm}=1.66$ (Hedges' correction applied), 95% CI for g_{rm} [0.95, 2.37]. Normality confirmed (Shapiro-Wilk $p=0.12$); no outliers (Tukey's). Variables controlled: Baseline anxiety, age, gender (covariates in ANCOVA, $F=2.1$, $p>0.05$).

Table 2. Descriptive Statistics (Preliminary Study).

Time Point	Mean (M)	SD	Min	Max
Pre	48.3	7.2	38	60
Post	36.2	6.5	28	48

Table 3. Paired t-Test Results.

Effect	Mean Difference	t	p	Effect Size (g)
Time	-12.1	-3.45	<0.01	1.66

6. Discussion

The findings suggest that Sedona-inspired digital interventions may help reduce emotional barriers in eLearning and support student engagement and well-being. By adapting emotional release techniques to virtual environments, the proposed framework extends existing approaches to distance education and highlights the potential of integrating emotional support into digital learning design.

Several factors may influence the effectiveness of the intervention, including gender, age, baseline anxiety levels, and cultural norms related to emotional expression. Future research should examine these moderators through larger, multi-site studies to assess generalizability across diverse contexts.

Despite its potential, the model faces practical limitations. Technical constraints, such as access to advanced tools (e.g., VR), and the need for cultural adaptation may affect implementation. Additionally, the preliminary nature of the data and the limited sample size restrict the strength of current conclusions.

Ethical considerations remain essential, particularly regarding data protection and psychological safety. Participant data should be anonymized and handled in compliance with GDPR standards. Potential emotional risks associated with release exercises require ongoing monitoring and appropriate support mechanisms.

From a theoretical perspective, the framework contributes to the integration of emotional regulation strategies within eLearning environments, positioning emotional well-being as a relevant dimension of instructional design.

Future work should focus on confirmatory randomized controlled trials, broader and more diverse samples, and the validation of outcome measures in educational settings.

7. Conclusions and recommendations

Integrating Sedona-inspired emotional release into eLearning platforms may represent a potential exploratory step toward resilient digital education, informed by conceptual principles and our preliminary 25% reduction. Policymakers could consider funding open-source tools, while educators might pilot micro-interventions. Future research: Longitudinal effects on academic outcomes and AI personalization, with preregistration to address biases. By exploring emotional health, we may help equip students for a volatile world—echoing the conference's vision of holistic human development, pending robust validation.

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FUNCTIONS OF THE SCHOOL AS A SPACE FOR PRESERVING ETHNOCULTURAL IDENTITY IN A FOREIGN ENVIRONMENT (ASPECTS OF THE WORK OF THE BULGARIAN SCHOOL IN CYPRUS)

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Abstract

The first mass migrations of Bulgarians date back to the period of Ottoman rule in the 17th century, continuing in the 19th century in two directions: northwest (present-day Austria, Hungary, and Romania) and northeast (present-day Russia, Moldova, and Ukraine). In the 20th century, Bulgarian migration was directed towards Central and Western Europe, South and North America. Migration processes were particularly intense after the changes in 1989, with Bulgarian communities now found in various countries and continents. In Bulgarian academia, emigration is usually divided into two groups: historical and contemporary, with the latter including emigration after 1989, which is also referred to as new emigration. One of the defining characteristics of this new emigration is the organisation and development of separate schools in the host country. The example of Bulgarian emigration to Cyprus is indicative of the approaches applied in schools, which, on the one hand, preserve the ethno-cultural identity of the community, but also facilitate the community's more immediate adaptation to the host country. The focus on two of the ten schools is not accidental. One school is located in the capital Nicosia, the other in the smaller town of Paralimni. A comparison between the programs and initiatives of the two schools highlights the importance of creating a cultural space as a place for expression, preservation, and development of ethnocultural identity. An important factor in the development of the schools is that their development is supported by Bulgarian organizations: in Nicosia, this is the Union of Bulgarians in Cyprus, and in Paralimni, it is the Bulgarian Cultural Association "Atanas Shabanov." This, in turn, further establishes schools abroad as cultural spaces for the expression of ethnocultural identity in a foreign environment.

Keywords: *Contemporary emigration, school, culture, identity, Bulgarian emigration to Cyprus.*

1. Introduction

It is well known that the process of globalization, associated with the intensification of migration processes and the movement of compact masses of population from one region or country to another, has an impact on the creation and development of ethnocultural communities within the host country. Analysts define this phenomenon as diasporization, which has its own characteristics and peculiarities. Research shows that in the course of its formation, each ethnocultural community uses cultural experience acquired from the country of origin and applies approaches that ensure both the preservation of national identity and support adaptation processes in the host country. This leads to the creation of cultural spaces for the manifestation of the ethnocultural nature of the community, for the restoration of historical memories and cultural meanings that bind its members together.

The example of the Bulgarian diaspora is indicative of the way in which the ethnocultural community has organized itself over the centuries, and the forms through which it has established itself and its identity. At the same time, examples from the present existence of the Bulgarian diaspora reveal new approaches not only to preserving but also to manifesting the ethnic uniqueness of the community through the creation of cultural spaces saturated with historically significant national symbols. A characteristic feature of these spaces is that they function as imagined in the sense of Benedict Anderson's classic formula: they become a concrete sign of the constructed national society (Anderson, 1998), united—regardless of their location—into a single cultural whole, with a common memory and collective recollections.

Researchers usually divide the Bulgarian diaspora into two groups: historical and contemporary. The formation of the historical diaspora dates back to the period of Ottoman rule—the first mass emigration of Bulgarians, who organized their communities in foreign territories, took place between the 17th and 19th centuries. The migration processes covered two directions: northwest (the territories of present-day Austria, Hungary, and Romania) and northeast (present-day Russia, Moldova, and Ukraine). During these centuries, communities of Banat Bulgarians (present-day Romania) as well as Tavrian and Bessarabian Bulgarians (present-day Russia, Moldova, and Ukraine) were formed. The historical communities also include the hundreds of Bulgarians who, as a result of international treaties and border changes at the end of the 19th and during the 20th century, found themselves within the borders of neighboring countries. Such are the Bulgarian communities in Serbia, Albania, Greece, and Turkey. The case of the so-called Macedonian citizens in North Macedonia is different, as the majority of them are genetically and culturally identical to the Bulgarian ethnic group.

The second group – the modern Bulgarian diaspora – formed at the end of the 19th and during the 20th century (particularly intensively during the first half of the century). The direction of migration was to Central and Western Europe, South and North America. Bulgarians, renowned for their agricultural skills, the so-called Bulgarian gardeners, settled in Hungary, the Czech Republic, Slovakia, and Austria, where they established their communities. In South and North America, immigrants of Bulgarian origin found their new home from the beginning of the 20th century and especially after the end of World War I. The migration processes following the political and economic changes in 1989 were particularly intense. Over a period of nearly thirty years, almost two million Bulgarians left their homeland and settled in various countries and regions. Researchers also define this diaspora as contemporary or new, thus linking its consolidation to the processes of community development in host countries that were characteristic of the 20th century (Borisova et al., 2017).

According to data from the State Agency for Bulgarians Abroad, today the largest Bulgarian communities are in the USA, Ukraine, Moldova, Greece, Spain, Germany, Austria, and Italy (IACB, https://www.aba.government.bg). Researchers of this type of newest Bulgarian diaspora define it as a contemporary or new Bulgarian diaspora. This includes the Bulgarian community in Cyprus, the study of which provides grounds for developing approaches and tools specific to the new Bulgarian diaspora for preserving ethnocultural identity and developing successful integration strategies for adaptation to the host country.

2. General information about the Bulgarian community in Cyprus

Bulgarians who have migrated to Cyprus rank third in terms of numbers among ethnic groups. The proximity of the island to Bulgaria, the similarities in terms of culture and civilization, and the climatic conditions favor the settlement of Bulgarians in Cyprus. Field research conducted by the authors in September 2025 (interviews and questionnaires) shows that the formation of a Bulgarian diaspora began after 1989, when, for economic reasons, hundreds of Bulgarians linked their future to the island. Bulgarians who settled in Cyprus work mainly in the tourism and restaurant sectors, as well as in the service industries.

Some of these Bulgarians retain their Bulgarian citizenship and do not plan to settle permanently in Cyprus. The interviews show that there are cases where one member of the family (most often the man) works in Cyprus while the woman remains in Bulgaria. In her 2013 study, S. Antova points out that it is common for Bulgarians who have been working in Cyprus since the beginning of the second decade of the 21st century to define themselves as mobile migrants – they work temporarily in a foreign country and then return to their homeland. Their families and/or children remain in Bulgaria, and their upbringing is entrusted to their closest relatives (grandparents) in cases where the family (mother and father) works on the island. (Antova, https://www.academia.edu).

This highlights a serious problem for the ethnocultural identity of Bulgarians in the first decade of the 21st century—the lack of opportunities to learn the Bulgarian language is perceived as an obstacle to the consolidation of the diaspora. It is no coincidence that Antova emphasizes that, apart from financial and economic factors, another serious reason for the separation of families is the lack of Bulgarian language education.The field research conducted by the authors of this article in September 2025 outlines a new situation. Firstly, Bulgarians have built their own communities, whose interests are institutionalized through the creation and development of Bulgarian non-governmental organizations: the Union of Bulgarians in Cyprus (based in Nicosia), the Bulgarian Cultural Association "Atanas Shabanov," the Union of Bulgarians in Paphos, Association of Bulgarian Teachers in the Republic of Cyprus – Larnaca, Union of Bulgarians in Limassol "Vazrazhdane," Association "Bulgarians Abroad" – Limassol, Bulgarian Cultural Center "Cyril and Methodius" – Nicosia, Bulgarian Organization "Rodna Stryaha." The main task of these Bulgarian organizations is to contribute to the preservation and development of the Bulgarian language, traditions, and culture.

The first organisation of Bulgarians in Cyprus was the Union of Bulgarians in Cyprus (UBC), which was founded in 1989 but only became active later, after it was established in the capital Nicosia in 1999. In the second decade of the 21st century, the UBC initiated the creation of five Sunday schools: "St. Clement of Ohrid" (Limassol), "Narodni Buditeli" (Paralimni), "Bulgarian School in Paphos," "Azbukarche" (Polis Chrysochous), "Nikola Vaptsarov" School (Nicosia), with a branch in Dali. The chairman of the BCC is Mr. Kalin Stoyanov (BCC, https://bguc.org/), and during the field research period, the BCC focused mainly on the development of the "Nikola Vaptsarov" school, headed by Ms. Lidia Stefanova.

Another organization representative of the Bulgarian community in Cyprus is the Bulgarian Cultural Association "Atanas Shabanov" (BKA), which carries out its initiatives and activities in the Famagusta region, with its center in the town of Paralimni. In 2020, the organization's activities included supporting the Saturday-Sunday school in Paralimni, "Narodnite Buditeli" (IABCH, https://aba.government.bg). The chair of the BKA is Ms. Maria Mavroudi, and the school's director is Ms. Zhivka Milova.

We focus our attention on these two Bulgarian organizations in Cyprus because of our focus on the schools that they develop and support. However, it should be noted that the other Bulgarian organisations in Cyprus also consider teaching the Bulgarian language and culture to be a key task in their work, supporting and developing Sunday schools. The total number of Saturday-Sunday schools in the Republic of Cyprus where Bulgarian language, Bulgarian history, and Bulgarian geography are taught. Firstly, the establishment of Saturday-Sunday schools is certified by their recognition by the Ministry of Education and Science of the Republic of Bulgaria, which also supports their work with teaching materials – textbooks and teaching aids, as well as with a state subsidy. Every year, the Council of Ministers of the Republic of Bulgaria approves a budget to support Bulgarian schools abroad in two areas. The first is the national program "Native Language and Program Abroad," in which all schools abroad are eligible to apply for support for their immediate needs to improve and expand their knowledge and skills in Bulgarian language and literature. The second is a specially adopted Decree of the Council of Ministers, which annually determines the subsidy for schools abroad as state aid for the implementation of their tasks (Ministry of Education and Science, https://world.mon.bg/).

3. The functional significance of the school’s name

It is indicative that all Sunday schools abroad, like the schools in Cyprus, bear names that are emblematic of Bulgarian culture. This also applies to the two schools in Nicosia and Paralimni. The patron of the school in Nicosia is the great Bulgarian poet Nikola Vaptsarov. In his classic poem "Letter," he sings of the big stars above Famagusta, the pearl of the Mediterranean. For every Cypriot, the name Famagusta is symbolic, carrying deep historical and contemporary meaning. So it is no coincidence that Vaptsarov's name was chosen for the school. In 2013, a bust-monument of Nikola Vaptsarov, created by Bulgarian sculptor Ivan Ikov, also an emigrant to the island, was placed in front of the school building. Vaptsarov's name has also become an opportunity for students to further study his work and poetic legacy, to organize recitals of the poet's poems and commemorative evenings.

His birthday and the day of his tragic death (Vaptsarov was a victim of Bulgarian fascism) are solemnly commemorated. On the other hand, the emphasis on Bulgarian poetry is an occasion for poets and writers from Bulgaria to visit the school during the educational process. Creative activities are initiated by the students, who try their hand at poetry and fiction. Therefore, in addition to the compulsory educational programs, the school also takes on additional functions as a guardian of ancestral memory, a creative laboratory for artistic innovation, and a communication center for the exchange of ideas and opinions between the children of migrants and representatives of the Bulgarian artistic and scientific-humanitarian intelligentsia. These initiatives strengthen and reinforce national identity and support the development of creative individuals who have the skills to engage in dialogue on key issues from history and the present day.

The second school is called "National Revivalists." In Bulgarian cultural memory, national revivalists are those representatives of literature—clergymen, writers, teachers—thanks to whom the Bulgarian people built themselves as a cultural nation in the 18th and 19th centuries. The name "revivalist" comes from the verb "to revive" and represents the personification of the act of activating the people's energy and will to create after centuries of slavery. In this school, along with the compulsory subjects of Bulgarian language, history, and geography, additional tasks are also accomplished. During their studies, students learn about Bulgarian awakening figures, reconstruct cultural memories, compile biographies, and draw parallels with similar cultural phenomena in Cypriot history. The Narodni Buditeli School also organizes a variety of events. Books from Bulgaria are presented, as well as exhibitions showcasing key national events. In September 2025, students attended the opening of the exhibition "155 Years of the

Bulgarian Exarchate" and received additional information about the enlightening and fundamental role of the Exarchate in maintaining and developing national identity. So here, too, the additional focus on cultural facts, cultural events, and the opportunity to understand them through the creation of a broader historical and cultural context is striking.

Both schools have signed cooperation agreements with schools in Bulgaria. Under the Erasmus program, students from the schools visit their Bulgarian partners, thus further consolidating their Bulgarian language skills and competences through observation and direct practice.

4. The school as an imaginary space for the development of ethnocultural identity

Studies show that the construction of the new emigration in Cyprus is also linked to the development of strategies for preserving and developing identity. Moreover, the establishment of schools where Bulgarian language, history, and geography are taught contributes to the fact that more and more mobile migrants prefer to be accompanied by their families during their commitments on the island. The schools are called Saturday-Sunday schools because the educational process takes place on the last two days of the week. The students are divided into classes according to age and are taught according to programs approved by the Ministry of Education and Science of the Republic of Bulgaria. Along with studying Bulgarian language, history, and geography, students are encouraged to look for analogies and comparisons—both diachronic and synchronic—with events and circumstances characteristic of Cypriot culture and history. In this way, the school begins to play an additional role in helping students adapt more quickly to their new environment.

The organizations responsible for the school's development further support the development of reading and writing skills and organize public exams where students demonstrate their knowledge of Bulgaria to their parents. The school grounds are filled with national symbols—copies of historical documents, portraits of important figures in Bulgarian culture, and paintings depicting the beauty of the homeland.In this way, the school fulfills two functions. On the one hand, it is a high-level educational space—students are taught on site, in specially designated classrooms - their workspaces, where they acquire the required competencies and develop skills in their native language, history, and geography. The teacher-student dialogue is conducted in the formal written Bulgarian language. On the other hand, the school is also establishing itself as a place for informal communication, where everyday life with its mundane details is also present. During breaks between classes, students freely communicate in Bulgarian, play, and develop their imagination, achieving the symbols of ethnocultural community. But the school also brings together parents and representatives of the Bulgarian community, who make important decisions about their activities and consolidation here. It turns out that Saturday-Sunday schools are beginning to fulfill the role of the imagined national territory. It is embodied both by the students and their parents, as well as by other representatives of the diaspora. On another level, it is the school that turns out to be the invisible thread that binds the nation into an indivisible whole, regardless of whether Bulgarians live abroad or in their homeland. Consequently, it acquires additional communicative, socializing, and cultural significance, which strengthens and develops the community in the host country.

5. Conclusion

The examples from Cyprus show that the creation and development of educational forms such as Saturday-Sunday schools, where the native language, history, and geography are taught, are of crucial importance for the preservation and development of ethnic and cultural identity and, in general, for the preservation of ancestral memory. On the one hand, Saturday-Sunday schools are the most appropriate form for learning the curriculum established by the country of origin and for applying established pedagogical approaches and methods of teaching the native language in a foreign environment. On the other hand, however, the school expands its territory, becoming a place for maintaining and developing ethnic and cultural identity. It is no coincidence that it embodies the idea of the Bulgarian nation, Bulgarian culture, and history with its specificity.

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ATTITUDES AND OPINIONS OF PRESCHOOL EDUCATORS AND ELEMENTARY SCHOOL TEACHERS REGARDING ECOLOGICAL EDUCATION AND THEIR AWARENESS OF SUSTAINABLE DEVELOPMENT

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Abstract

The aim of this research paper is to examine the attitudes and opinions of preschool educators and elementary school teachers regarding ecological education and their awareness of sustainable development. The research is based on both qualitative and quantitative analysis of data collected through questionnaires and interviews with teachers from various educational institutions. The objectives of the research are to determine: The attitudes of teachers towards ecological education; The level of environmental awareness among teachers; The presence and method of integration of environmental content into the educational process; The needs for additional training and resources for the successful implementation of ecological education. A descriptive methodology was applied, using surveys and semi-structured interviews as the main research techniques. The target population includes educators working in public and private preschool institutions and elementary schools (grades I–III) across several municipalities in the Republic of North Macedonia. The sample consists of 50 preschool educators and 50 elementary teachers (grades I–III). The sample was selected using purposive sampling, in order to include respondents with various levels of experience, institutional affiliation, and geographical distribution (urban/rural). The results indicate that the majority of teachers recognize the importance of ecological education and its role in building environmental awareness among children from an early age. However, differences exist in the level of engagement, availability of resources, and institutional support. Elementary school teachers tend to have more theoretical knowledge than preschool educators, whereas preschool educators possess more practical knowledge than elementary school teachers. This can be explained by the fact that the knowledge gained by elementary school teachers during university studies is relatively new and limited in practical application, as they spend less time with children during applied coursework. In conclusion, the paper emphasizes the need for more systematic teacher training, integration of environmental topics into curricula, and the promotion of active learning approaches for sustainable development from an early age.

Keywords: *Ecological education, sustainable development, teachers, preschool age, elementary school teachers, environmental awareness.*

1. Introduction

Sustainable development represents one of the central challenges of contemporary society, aiming to balance ecological, economic, social, and political dimensions while offering long-term solutions to global problems (UNESCO, 2017; UNESCO, 2020; Rieckmann, 2018). Education for Sustainable Development (ESD) has emerged as a significant policy and educational response, playing a central role within the 2030 Agenda and the Sustainable Development Goals, particularly Target 4.7 of Sustainable Development Goals 4 (UNESCO, 2017). Its implementation is essential at all levels of education, with schools serving as a key setting and teachers acting as primary agents in promoting sustainability (Baumert and Kunter, 2006; Darling-Hammond, 2000).

Recent studies show that teachers' attitudes and perceptions significantly affect the implementation of ecological education and Education for Sustainable Development. Even when knowledgeable, educators' beliefs, values, and environmental awareness influence the integration of sustainability topics into teaching (Waltner, Scharenberg, Hörsch, and Rieß, 2020; Loupas, Zafeiropoulos, Martinis, Mallinou, & Kouveli, 2026). Teachers exposed to Education for Sustainable Development training demonstrate higher environmental responsibility and are more likely to promote sustainable

behaviors among students (Yaacob and Abdullah, 2023; Jácome, 2019). Early childhood and primary education are particularly important for fostering environmental awareness, as children develop foundational behavioral patterns and worldviews during these stages (Davis, 2015; Loupas et al., 2026).

By addressing these aspects, the study intends to provide insights into how educators' competences, perceptions, and professional preparedness influence the quality of ecological education and the promotion of sustainable behaviors among young learners. Ultimately, the findings aim to inform teacher education programs and policy initiatives, supporting the development of effective strategies for integrating sustainability into early and primary education.

2. Theoretical framework

2.1. Ecological education – concept and meaning

Ecological education is a systematic process aiming to develop awareness of the importance of nature protection and to encourage active participation in solving environmental problems. It includes the following components:

- Cognitive component includes the ability for critical thinking, recognizing sustainable practices, and understanding the importance of early ecological education for forming responsible future citizens.
- Affective component refers to the emotions, value orientations, attitudes and sense of personal responsibility of preschool teachers and initial education teachers in relation to ecological education and sustainable development. The affective component is the key component because positive attitudes and emotions towards ecology are the basis for forming lasting environmental awareness and for transmitting sustainable values among children.
- The behavioral component refers to specific behavior, habits and practical activities of preschool and initial education teachers regarding ecological education and sustainable development
- The behavioral component reflects the real application of knowledge and attitudes in practice and is a key indicator of the level of developed environmental awareness and professional engagement in the field of sustainable development.
- Activist component willingness to participate in environmental projects and actions**.** In preschool institutions, ecological education is most often implemented through practical activities with children, such as outdoor activities, care for plants, environmental projects, recycling of materials, and themed games.

2.2. The role of teachers and preschool educators in developing environmental awareness and culture

Teachers and preschool educators play a key role in the formation of environmental awareness and culture in children, especially in preschool education and initial (from first to third grade) elementary education. They are the first models of behavior and values that children follow and their role is manifested on multiple levels.

Behavior and culture modeling

- Teachers and preschool educators are role models for children who follow their actions and habits.
- Teacher's personal engagement in environmental projects, actions, and initiatives encourage children to undertake similar activities.
- Through consistent and complete display of environmental values, teachers form a culture of sustainability as part of children's daily lives.

Interdisciplinary role

- The development of environmental awareness is not limited to the study of natural sciences.
- Teachers and preschool educators can integrate environmental content into language, art, mathematics, and humanities, which enables comprehensive learning and internal acceptance of environmental culture.

3. Methodology

3.1. Research aims and nature

The aim of the research is to examine the attitudes and opinions of preschool teachers and initial education teachers (from first to third grade) in elementary education about environmental education and their awareness of sustainable development.

The research included 120 respondents, of which 65 were preschool educators and 55 were teachers from grades 1–3 in elementary education.

The study was conducted using questioner as instrument and interview techniques to collect data. Through these techniques, the attitudes and opinions of preschool educators and teachers in initial education (from first to third grade) in elementary education regarding environmental education and their awareness of sustainable development will be determined. The questionnaires contain specially formulated questions related to the subject of study, such as: the attitudes and opinions of preschool educators and initial education teachers (from first to third grade) in elementary education about environmental education and their awareness of sustainable development.

4. Research results

From the results obtained from the survey conducted, regarding views on the importance of ecological education, 90% consider it as "very important", 8% "important" and 2% "less important". The results show that almost all respondents understand the key role of ecological education.

Preschool educators and teachers in initial teaching were asked whether they practiced ecological habits. 70% of respondents said they did so regularly, 25% occasionally and 5% rarely. The most common activities listed were: recycling, saving electricity, reducing the use of plastic and using ecological materials.

As for the implementation of environmental content in teaching practice, 80% of preschool educators stated that they regularly implement environmental activities, 65% use recycled materials in children's centers and 55% organize outdoor activities at least once a week.

Among teachers from initial teaching, 60% implement environmental content in at least 2 subjects, 40% realize project assignments with environmental topics and 35% participate in school environmental actions.

The inconsistencies faced by preschool educators and initial education teachers were: lack of sufficient materials 40%, lack of professional development 20%, lack of time and an overloaded curriculum 30%, and insufficient institutional support 10%. The need for more training, practical workshops, examples of good teaching planning, ready-made teaching materials, and implementation of environmental projects for working with young children were also stated.

Table 1 shows the results of the descriptive statistics of the main scales used in the research. Descriptive statistics provide insight into the basic characteristics of the respondents' results on the main scales, through arithmetic mean, standard deviation, minimum and maximum values.

Table 1. Descriptive statistics of the main research scales.

SCALE	M	SD	Min–Max	Interpretation
attitudes and opinions of preschool educators and teachers regarding environmental education **(10 items)**	**4.36**	0.52	3.1–5.0	High
level of personal environmental awareness **(5 items)**	**4.11**	0.61	2.5–5.0	Medium high
degree of implementation of environmental content in teaching practice **(5 items)**	**3.54**	0.78	1.3–4.8	Medium high
Perception of sustainable development (5 items)	**4.28**	0.57	2.6–5.0	High

To determine the reliability of the research instrument, the Cronbach's internal consistency coefficient was applied, which ranges from 0.83 to 0.89, indicating high internal consistency of the scale (Table 2).

Table 2. Cronbach's internal consistency coefficient.

To determine the attitudes and opinions of preschool educators and teachers regarding ecological education **(10 items)**	**α = 0.89**
To assess the level of personal environmental awareness (5 items)	**α = 0.83**
To examine the degree of implementation of environmental content in teaching practice **(5 items)**	**α = 0.75**
Perception of sustainable development (5 items)	**α = 0.86**

Table 3. Correlation analysis.

Variables	1	2	3	4
1. Attitudes	1	.56**	.48**	.62**
2. Personal awareness	—	1	.44**	.58**
3. Implementation	—	—	1	.41**
4. Sustainable development	—	—	—	1

**p < .01 *p < .05

Table 3 presents the results of the correlation analysis between the main research variables. The correlations were calculated using the Pearson correlation coefficient (r). The obtained correlation coefficient indicates statistical significance level of $p < 0.01$.

The questionnaire consisting of 10 questions to determine the attitudes and opinions of preschool educators and teachers regarding environmental education, shows a strong and statistically significant positive correlation with the perception of sustainable development ($r = 0.62$, $p < 0.01$), as well as moderate positive correlations with the level of personal environmental awareness ($r = 0.56$, $p < 0.01$) and the degree of implementation of environmental content in teaching practice ($r = 0.48$, $p < 0.01$). The level of personal environmental awareness is in a moderate and statistically significant positive correlation with the degree of implementation of environmental content in teaching practice ($r = 0.44$, $p < 0.01$) and a strong positive correlation with the Perception of Sustainable Development ($r = 0.58$, $p < 0.01$). The implementation of environmental content in teaching practice shows a moderate, but statistically significant positive correlation with the Perception of sustainable development ($r = 0.41$, $p < 0.01$). Generally, the results indicate the existence of moderate to strong positive correlations between all examined variables, indicating their mutual connection.

The correlation analysis showed the existence of statistically significant positive correlations between all investigated variables. The strongest correlation was determined between the attitudes and opinions of preschool educators and teachers regarding ecological education and the Perception of sustainable development ($r = 0.62$), while the Implementation of environmental content in teaching practice shows moderate but significant dependencies with the other variables. Stronger positive correlations exist between the attitudes and opinions of preschool educators and teachers regarding ecological education, the level of personal environmental awareness, and the perception of sustainable development. The implementation of environmental content in teaching practice has moderate but significant correlations with the other scales → indicating that attitudes and awareness influence practical realization.

Our results, that preschool educators and teachers have positive attitudes towards environmental education and high awareness of sustainable development, are in line with international research on Education for Sustainable Development. For example, Waltner et al. (2020) point out that teachers have a high level of knowledge and positive attitudes towards sustainable development, but that they lack structural support and specific teaching materials for effectively integrating Education for Sustainable Development in the classroom, which indicates the need for more practical and continuous application in the teaching process. The study by Yaacob and Abdullah (2023) confirms that teachers have a high level of knowledge and positive attitudes about education for sustainable development, but that their practical application is sometimes moderate, indicating the challenges in transforming attitudes into active practices. These results partially coincide with our results, where positive attitudes and awareness of sustainable development are strongly expressed ($M = 4.32$; $M = 4.25$), but practical implementation in the educational process depends on factors such as work experience and professional training. Waltner et al. (2020) suggest that the barrier between attitudes and practical application often remains due to institutional and pedagogical constraints, and they are consistent with our findings that teachers have positive attitudes but sometimes face systemic challenges in integrating environmental content. Professional training that in our research showed a significant effect on attitudes ($t = 2.78$, $p = 0.006$), is also supported by the study by Jácome (2019), which shows that formal education for sustainable development significantly influences students' attitudes as future teachers, which in turn highlights the importance of training and continuous professional development. Additionally, Kouveli (2025) points out that teachers in different contexts support educational work for sustainable development but point to the need for ongoing state and institutional support for the successful implementation of these programs.

The results obtained in our research, compared with foreign literature, show that the positive attitude and awareness of sustainable development, observed in our research, are part of a global trend that emphasizes the importance of ecological education, professional training, the availability of materials for the implementation of practical activities, and systemic support for the application of the principles of sustainable development in the educational process.

Table 4. Frequency analysis of obstacles to implementing ecological education activities.

Disadvantage	%
Lack of materials	**62%**
Lack of time	**55%**
Insufficient institutional support	**48%**
Lack of training	**43%**
Overcrowded groups	**41%**
No yard	23%
Low parental support	18%

Frequency analysis was applied in order to identify the most common obstacles to implementing ecological education activities that respondents face. Table 4 presents the results of the frequency analysis that show that the most frequently cited obstacle to the realization of ecological education activities is the lack of materials (62%), which indicates serious limitations in the resources for implementing the activities. Significant shortcomings include lack of time (55%) and insufficient institutional support (48%), which points to organizational and systemic difficulties in practical implementation. Lack of training (43%) and overcrowded groups (41%) are also relatively frequently present obstacles, indicating the need for additional professional development and improvement of working conditions. On the other hand, disadvantages such as lack of a schoolyard (23%) and low parental support (18%) are less prevalent, indicating that they represent a limitation for a smaller portion of respondents.

5. Discussion

The results obtained from the interview conducted with the respondents show that preschool educators and teachers have strong, positive attitudes, but practical application is limited. This gap between attitudes and practice is a common occurrence in ecological education. The most common reasons cited are lack of resources, insufficient institutional support, lack of time, and little representation of environmental content in curricula.

The results of the research indicate that highly developed positive attitudes and awareness of including environmental content (average 4.11/5) in teaching indicate readiness and motivation among preschool educators and teachers, which means that they are aware of the importance of sustainable development and actively integrate this awareness into everyday life and pedagogical practice. However, it is important to note that positive attitudes do not always translate directly into practical application due to certain obstacles, such as lack of materials, time, and institutional support. These results confirm that for successful implementation of ecological education, it is necessary to additionally provide systemic support, professional development and development of specific curriculum and activities. Developed awareness and positive attitudes are a key factor for effective ecological education. They create a foundation for further development of practical activities and initiatives that contribute to building sustainable and environmentally conscious generations.

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SUSTAINABLE EDUCATION IN WRITTEN HERITAGE CONSERVATION: INCORPORATING ENVIRONMENTAL PRACTICES INTO STUDENT TRAINING

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Abstract

Contemporary education in the conservation and restoration of written heritage requires not only technical skills but also awareness of environmental responsibility and sustainability. This report presents approaches for integrating sustainable practices into student training, aiming to develop professionals capable of preserving archives, manuscripts, and rare books with minimal environmental impact. Key elements include the use of eco-friendly materials, energy-efficient storage conditions, safe conservation methods, and the implementation of digital technologies for monitoring and documentation. The training combines theoretical lectures, hands-on workshop experience, and project-based assignments, enabling students to apply sustainable methods in real conservation projects. The report will discuss the educational benefits, scientific challenges, and opportunities for scaling the approach to other curricula and institutions. The goal is to demonstrate how sustainability can become a central component of the educational process, fostering environmental thinking, critical approaches to heritage preservation, and professional ethics.

Keywords: *Education, conservation, written heritage, environmental strategy.*

1. Introduction

Written cultural heritage represents a key element of human civilization, preserving historical, cultural, and scientific information that is fundamental to the identity of societies (Vadrucci, 2025). Manuscripts, archival documents, and early printed books provide knowledge about historical processes, linguistic and cultural characteristics, as well as social transformations (Niu, Wang & Bi, 2025). Their preservation ensures continuity between generations and provides access to the facts, ideas, and practices that have shaped the modern world.

Contemporary conservation of written heritage faces numerous challenges, including the degradation of paper and inks, biological damage, unfavourable climatic conditions, and lack of resources (Shehata, Al-Khatib & Mostafa, 2022). In the context of climate change, ensuring sustainable and safe storage methods becomes critical for the long-term safeguarding of collections (Hidalgo Sánchez, 2022).

The need for environmentally responsible practices in conservation includes the use of non-toxic materials, minimizing waste, optimizing energy resources, and integrating preventive measures that extend the life of documents without compromising their integrity (Mazzetto, Bianchi & Rossi, 2023).

The aim of this report is to analyse the integration of sustainable and environmentally oriented methods in the education of conservation and restoration of written heritage. The report focuses on practical approaches for implementing "green" standards, demonstrating new technologies, and training future specialists to balance cultural heritage preservation with ecological responsibility.

2. Pedagogical models

2.1. Pedagogical models integrating traditional knowledge with sustainable practices

Education is one of the highest values in any society, strongly influenced by economic, social, demographic, and political changes. Under these conditions, the goal of educational institutions should be to create a supportive environment and optimal conditions for the development of students' abilities, fostering their creativity and problem-solving skills (Savova, E., Stoyanova, D., & Petrova, T., 2023).

Education in conservation and restoration requires a combination of theoretical knowledge and practical skills, as students must master both the scientific principles and technical methods necessary for preserving written cultural heritage. The main pedagogical models include:

- **Traditional lecture-based learning:** Provides foundational knowledge in art history, materials science, and conservation techniques.
- **Practice-based learning:** Students gain hands-on experience in laboratories, applying theoretical knowledge to real objects.
- **Project-based learning:** Involves participation in real restoration projects, developing competencies in planning, risk assessment, and practical problem solving.
- **Interdisciplinary approach:** Integrates art, chemistry, biology, physics, digital technologies, and cultural heritage management, preparing students to address complex professional scenarios.

These models are often combined to create a holistic educational framework, fostering not only technical expertise but also analytical and critical thinking skills.

2.2. Sustainable education and environmental awareness in the academic context

Sustainable education emphasizes the integration of environmental, social, and economic considerations into the learning process. In the context of written heritage conservation and restoration, this entails:

- Promoting environmental awareness among students, enabling them to understand the ecological impact of conservation practices.
- Incorporating sustainable methods into the curriculum, such as the use of non-toxic materials, minimizing chemical agents, and implementing energy-efficient storage technologies.
- Teaching social and professional responsibility, including ethical decision-making in restoration, risk assessment, and the preservation of the authenticity of objects.
- Encouraging critical thinking and evaluation of practices, empowering students to make informed decisions regarding sustainable conservation methods.

Sustainable education is not merely an adjunct to conventional learning but an integral component of professional training, shaping future specialists with ecological consciousness and ethical responsibility.

The implementation of sustainable and environmentally responsible practices requires an integrated approach that encompasses not only the preservation of natural resources but also social sustainability. This includes ensuring equal access to education and creating fair opportunities for all members of society while promoting social engagement (Nusheva, Kamelia, & Hadzhieva, Boryana, 2025). Adopting the principles of environmentally, responsible conservation not only mitigates the negative environmental impact of professional practices but also fosters a culture of sustainability and accountability within academic conservation programs.

3. Teaching methodology

3.1. Integrating sustainable practices into the curriculum

Education in the conservation of written heritage incorporates sustainable practices through:

- **Selection of low-impact materials:** Use of non-toxic conservation agents, biodegradable and recyclable packaging, and environmentally friendly cleaning products.
- **Energy-efficient storage techniques:** Optimization of temperature, humidity, and lighting in archives and laboratories, with the use of renewable energy sources whenever possible.
- **Digitization and monitoring:** Implementation of 3D scanning, databases, and monitoring software to reduce physical impact on the objects.

3.2. Practical laboratory exercises

The objective is to provide hands-on experience that combines classical conservation with environmentally conscious practices. Students participate in real conservation and restoration processes, applying sustainable methods to archival documents and rare books. Laboratory exercises include demonstrations of safe techniques with various materials and experimental approaches for long-term preservation.

3.3. Project-based learning and simulations

Projects aim to develop critical thinking, planning, and risk assessment skills, which are essential competencies for future professionals. Students work in interdisciplinary teams to develop pilot projects for the sustainable preservation of written heritage.

Sample tasks include:

- Developing strategies for archive storage with minimal energy consumption.
- Analysing the environmental and material impact of different chemical agents on documents.
- Simulating conservation and restoration processes with an assessment of material sustainability.

3.4. Interdisciplinary approach

- Combines art, chemistry, physics, information technology, and cultural heritage management.
- Enables students to perceive conservation as a complex process encompassing technical, ecological, ethical, and organizational aspects.
- Fosters skills in innovation and adaptability, which are essential in contemporary professional practice.

3.5. Learning objectives and expected outcomes

- Students acquire competencies in sustainable conservation techniques.
- Develop environmental awareness and professional ethics.
- Gain interdisciplinary skills and critical thinking abilities applicable to real-world restoration projects.
- Projects have the potential for practical implementation in heritage preservation institutions while minimizing ecological impact.

Through seminars, discussions, and case studies, students cultivate environmental awareness and critical perspectives on conservation practices. Topics include ethics, authenticity, social responsibility, and the long-term environmental impact of methods. This approach fosters a professional culture of sustainability that students can apply both in academic settings and throughout their future careers.

4. Educational outcomes and challenges

This component summarizes the key educational benefits, skills acquired by students, and existing challenges, while also proposing specific strategies to optimize the learning process.

- **Benefits for students:** Development of professional competencies enhanced environmental awareness, and stimulation of critical thinking.
- **Scientific and practical challenges:** Identification of difficulties related to integrating theoretical and practical knowledge, limited resources, and the need to adapt teaching approaches to diverse educational contexts.
- **Recommendations for implementation in other academic programs:** Formulation of strategies for transferring best practices, adapting teaching materials and methods, and promoting interdisciplinary collaboration to increase the effectiveness and sustainability of the educational process.

4.1. Educational outcomes

- **Competencies and skills:** Students acquire both practical and theoretical knowledge of sustainable conservation techniques, including the use of environmentally friendly materials, digital technologies, and energy-efficient storage methods.
- **Environmental awareness:** Participation in projects helps students understand the environmental impact of conservation practices and the importance of sustainable approaches.
- **Critical thinking and problem solving:** Project-based learning and simulations foster analytical thinking and risk assessment capabilities in various restoration strategies.
- **Interdisciplinary skills:** Students develop competencies in art, science, technology, and cultural heritage management, preparing them for complex professional situations.
- **Ethics and professional responsibility:** Students cultivate values such as object authenticity, social responsibility, and attention to sustainability.

4.2. Scientific and practical challenges

- Lack of standardized methodologies for integrating sustainable practices in conservation.
- Limited resources – material, technological, and financial constraints in implementing environmentally friendly techniques.
- Heterogeneous student preparation – varying levels of knowledge in chemistry, physics, and technology may complicate the application of an interdisciplinary approach.
- Need for curriculum adaptation – integrating sustainable practices requires modifications to study plans and faculty training.

4.3. Recommendations for improvement

- Development of pilot programs and case studies that demonstrate the effectiveness of sustainable approaches.

- Incorporation of international standards and best practices for written heritage preservation.
- Mentoring and training of instructors in environmentally conscious thinking and sustainable conservation.
- Promotion of collaboration between universities, museums, and archives to create real-world conditions for applying ecological strategies.

5. Conclusion

Education in the conservation and restoration of written heritage is critical for safeguarding cultural memory, while contemporary challenges necessitate the integration of sustainable and environmentally responsible practices. This report demonstrates that incorporating ecological strategies into the curriculum fosters the development of professional competencies, environmental awareness, and ethical standards among students.

The combination of theoretical lectures, practice-based learning, and an interdisciplinary approach ensures the acquisition of skills for safe and effective conservation, while simultaneously minimizing negative environmental impact. Projects and simulations stimulate critical thinking, risk analysis, and innovation, preparing students for real professional scenarios in libraries, museums, and archives. Implementing sustainable practices not only enhances the quality of the educational process but also cultivates a culture of long-term environmental and social responsibility among future professionals.

To achieve sustainable outcomes, active collaboration between universities, cultural institutions, and international organizations is recommended, along with curriculum adaptation and continuous professional development of instructors. Integrating sustainable practices into educational programs in the conservation and restoration of written heritage represents not only an opportunity for professional advancement but also a key factor in preserving cultural heritage for future generations. This approach aligns with global practices and current trends in cultural heritage preservation.

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LITERATURE ANALYSIS ON THE APPLICATION OF MACHINE LEARNING ALGORITHMS FOR THE PREVENTION OF UNIVERSITY DROP OUT

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Abstract

Education is a fundamental human right, established by international agreements such as the Sustainable Development Goal 4, which promotes an inclusive and quality education. In Mexico, upper secondary and tertiary education exhibit the highest student dropout rates, adversely impacting social equity, employment opportunities, economic development, and the sustainability of educational institutions. In response to this challenge, machine learning, artificial intelligence, and deep learning techniques have emerged as relevant tools for the early prediction of student dropout and the development of more effective retention strategies. The aim of this study was to systematically analyze recent literature on predictive models applied to dropout in higher education, identifying the most effective algorithms and the key factors influencing the phenomenon. The methodology followed the PRISMA framework for systematic reviews. Searches were conducted in the Scopus and Web of Science databases covering publications from January 2020 and April 2025. After removing duplicate records, applying JCR indexing criteria, and assessing thematic relevance, 45 high-impact studies were selected. The data were subsequently organized and analyzed using tabular and graphical tools in RStudio. The results indicate that the most effective algorithm is Random Forest, particularly when combined with balancing techniques such as SMOTE Tomek Links, achieving performance metrics above 99%. The most influential factors were found to be current academic performance variables, followed by socioeconomic and admission factors. The analysis confirms the feasibility of implementing predictive models in higher education to reduce student dropout, providing to academic administrators valuable information to target support measures and enhance the efficiency of the educational system. In the specific case of a private institution such as the Universidad Popular Autónoma del Estado de Puebla (UPAEP), implementing the most effective dropout prediction algorithm would have a positive impact by enabling early and personalized interventions for at-risk students, helping them overcome academic, financial, or emotional challenges, and promoting their retention and academic success. Faculty members would have better tools to identify and support at-risk students, strengthening academic support. These actions are expected to significantly reduce dropout rates, optimize institutional resources, and reinforce the university's academic reputation.

Keywords: *University dropout, predictive factors, machine learning, prediction models.*

1. Introduction

Education is a fundamental human right recognized worldwide through Article 26 of the Universal Declaration of Human Rights, which states that everyone has the right to education (Organización de las Naciones Unidas, 2024a). This principle is reinforced by the Sustainable Development Goal 4 (SDG 4), which aims to ensure inclusive and equitable quality education and promote lifelong learning opportunities for everyone (Organización de las Naciones Unidas, 2024b). Within this framework, the United Nations Educational, Scientific and Cultural Organization (UNESCO) plays a central role in promoting the right to education by strengthening education policies, teacher training, infrastructure improvements, and the strategic integration of emerging technologies, including artificial intelligence, with the goal of eliminating structural barriers that limit access to and retention in school (UNESCO, 2024).

In Mexico, the national education system has aligned itself with these international commitments through reforms aimed at improving educational coverage and quality. The 2020–2024 Sectoral Education

Program establishes, among its priority strategies, the consolidation of support and school coexistence programs to reduce school dropout rates and improving graduation rates, strengthening the transition between levels and modalities of the education system (Secretaría de Educación Pública, 2020). However, despite the reported progress, official statistics indicate that dropout rates remain higher at the upper secondary and higher education levels, maintaining a downward trend in recent decades (Instituto Nacional de Estadística y Geografía (INEGI), 2025). This phenomenon has profound implications by contributing to a reduction in employment opportunities, being associated with lower wages, and contributing to higher levels of informality (Bentaouet Kattan & Székely, 2015).

University dropout is a complex and multidimensional phenomenon that does not stem from a single cause, but rather from the interaction of academic, socioeconomic, institutional, and personal factors that influence students' educational trajectories (Barragán Moreno & González Támara, 2024). Abandoning higher education represents a crucial challenge for higher education institutions, due to its negative impact on both students and society (Vaarma & Li, 2024). In this sense, university dropout has been defined as the premature abandonment of an academic program before obtaining the corresponding degree, once a sufficient period has elapsed to rule out the student's readmission, and it can be analyzed from psychological, economic, sociological, organizational, and interactional perspectives (Jiménez-Gutiérrez et al., 2024).

Over the past two decades, the increasing availability of digitized educational data has fostered research aimed at the early prediction of dropout rates using machine learning, artificial intelligence, and deep learning techniques. These approaches have proven useful in both online and face-to-face educational contexts. Recent studies have identified algorithms such as neural networks, boosting models, and ensemble methods as effective tools for predicting dropout rates, as well as the relevance of academic and interaction variables on LMS platforms to explain this phenomenon (Urteaga et al., 2020; Fernandez-Garcia et al., 2021; Rebelo Marcolino et al., 2025; Vaarma & Li, 2024). However, literature reviews warn of fragmented approaches, heterogeneous definitions of dropout, and limitations in the explanatory power of purely automated models, underscoring the need for systematic and integrative analyses (Elibol & Bozkurt, 2023; Parra-Sánchez et al., 2023). In this context, given that student dropout is a core issue for any educational institution and considering that the highest dropout rates in Mexico occur in upper secondary and higher education, this research focuses on analyzing the literature on the application of machine learning, artificial intelligence, and deep learning methods for the early prediction of university dropout. The proposed literature review seeks to answer the following questions: 1) what algorithms have been used for predicting and preventing university dropout, and which are the best based on validation metrics? And 2) what factors significantly determine university dropout?

2. Methodology

The study was based on a systematic literature review focused on analyzing research that uses machine learning, artificial intelligence, and deep learning algorithms to predict student dropout rates in higher education. The review encompassed publications from January 2020 to April 2025 and was structured according to the PRISMA guidelines, following three main stages: article search, study selection and registration, and data extraction and analysis (Page et al., 2021). Publications were identified in the Scopus and Web of Science databases using a search strategy applied to document titles that combined terms related to student dropout and predictive approaches based on artificial intelligence. An initial 261 articles were identified, of which, after removing duplicates, 174 unique publications were obtained.

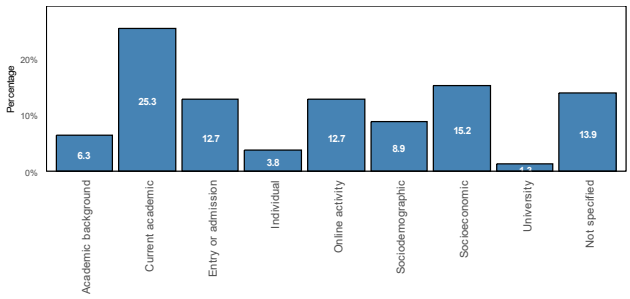
In a second stage, the studies were subjected to more restrictive selection criteria, considering only articles indexed in journals included in the Journal Citation Reports (JCR) and with open access to the full text. Subsequently, an additional filter was applied, prioritizing publications ranked in the 50th percentile or higher of the JCR and focused on higher education student dropout rates. This resulted in the final selection of 45 articles for detailed analysis. Data extraction was carried out by consolidating the records into a unified database, followed by a thorough reading of each study to identify key information related to samples, variables, predictive algorithms, and evaluation metrics. The analysis was supported by tabular and graphical tools implemented in RStudio.

Finally, due to the heterogeneity and large number of variables reported in the analyzed studies, a categorization strategy based on previous proposals in the literature was adopted, complemented by an additional dimension of online activity, in order to distinguish between face-to-face and virtual modalities (de Oliveira et al., 2021). This categorization allowed the variables to be organized into eleven analytical dimensions: academic background, entry or admission, current academic, final academic, online activity, individual, socioeconomic, sociodemographic, external support, environment and university.

3. Results

The study's findings show a clear predominance of supervised learning algorithms, particularly those based on decision trees and ensemble methods. Among these, Random Forest (RF) stands out as the most widely used and best-performing algorithm overall, accounting for 13.3% of individual applications and reaching nearly 19.9% when combined with other algorithms or balancing techniques; other relevant models include Categorical Boosting, Decision Tree, k-Nearest Neighbors, and Logistic Regression. Regarding the factors that significantly determine university dropout rates, the results show a clear consensus on the centrality of current academic variables, which represent 25.3% of the identified influencing factors. These include indicators such as overall GPA, number of credits earned, courses not passed, percentage of courses successfully completed, and attendance. Second are socioeconomic factors, with an incidence of 15.2%, followed by entry or admission variables and those associated with activity on online learning platforms (figure 1).

Figure 1. Important dimensions.



The comparative analysis by educational modality reveals that, although current academic variables maintain a similar relevance in both modalities, there are significant differences in other dimensions. For example, “In person” modality, entry or admission factors and socioeconomic factors carry more weight, while in the online modality, variables associated with activity on LMS platforms are clearly predominant (Figure 2). Likewise, when differentiating by educational sector, it is identified that current academic factors are more relevant in the private sector, while in the public sector, entry factors and online activity variables carry more weight (Figure 3).

Figure 2. Important dimensions by modality: online (blue) face-to-face (red).

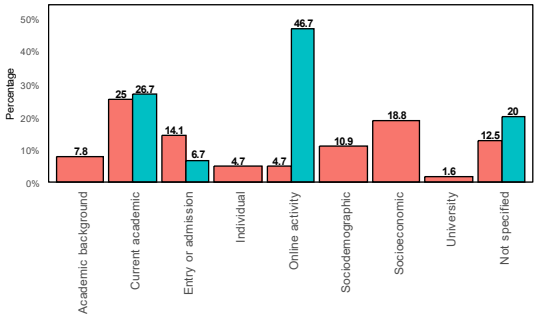
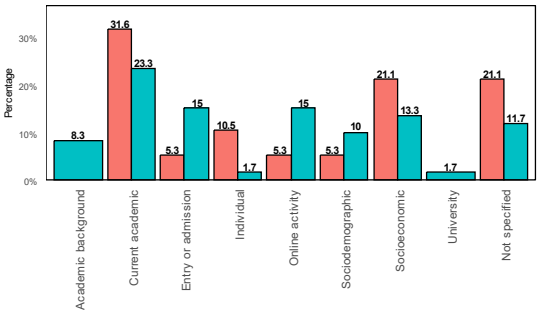


Figure 3. Important dimensions by sector: private (red) and public (blue).



Finally, the supplementary analysis reveals that most studies are conducted in public institutions and in person educational settings. Research with institutional coverage predominates, based primarily on internal data generated by the educational institutions themselves. Furthermore, a trend toward multidisciplinary approaches is observed, as well as a wide geographical diversity in the analyzed studies. In terms of computational tools, Python emerges as the most widely used programming environment, followed by R, reflecting current preferences in the development of predictive models applied to university dropout rates.

4. Discussion

The analysis of the algorithms used reveals a clear predominance of methods based on decision trees and ensemble techniques, particularly Random Forest, which is consistent with previous studies in educational data mining (Andrade-Girón et al., 2023; Dekker et al., 2009). Several studies report that these models achieve high levels of performance, especially when combined with class balancing techniques

such as SMOTE-Tomek Links (Fernández-Delgado et al., 2014; Kumar et al., 2024). However, the discussion cautions that extremely high metrics should be interpreted with care, as they may reflect overfitting, biases derived from preprocessing, or particular characteristics of the datasets, rather than generalizable performance. Furthermore, the observed methodological heterogeneity—stemming from the diverse use of balancing techniques (Chen et al., 2020; Fernandez-Garcia et al., 2021) and explainable artificial intelligence approaches (Delen et al., 2024; Rebelo Marcolino et al., 2025)—hinders direct comparison between studies. This situation is reinforced by the variability in the validation metrics employed, where accuracy continues to predominate despite its limitations in contexts of unbalanced classes (Herzog, 2006). Regarding predictor variables, there is broad consensus on the centrality of current academic indicators, such as grade point average, accumulated credits, and failed courses, as the most consistent predictors of university dropout (Kocsis & Molnár, 2025). This finding is consistent with the classic literature on student dropout (Bean, 1979; Tinto, 1993). However, the recurring exclusion of socioeconomic, personal, and contextual variables limits the explanatory power of the models and reinforces the need to understand university dropout as a socially situated and structural phenomenon (Cabrera et al., 1992; Parra-Sánchez et al., 2023). In this sense, the importance of moving towards more transparent, explainable, and socially responsible approaches to the use of artificial intelligence in education is emphasized (Holstein et al., 2019; Williamson & Eynon, 2020).

5. Conclusions and limitations

The systematic review successfully answered the research questions and achieved the stated objectives by providing a structured synthesis of the methodological, algorithmic, and explanatory approaches used to predict university dropout. The findings reveal a clear predominance of ensemble algorithms, particularly Random Forest, which emerges as the most frequently employed method and the one with the best reported performance in the analyzed studies, both as a standalone classifier (13.3%) and in combination with other models or class-balancing techniques (19.9%). The analysis of factors associated with university dropout, based on eleven dimensions, indicates that current academic characteristics constitute the most influential dimension (25.3%), followed by socioeconomic characteristics (15.2%). However, the predominant use of ensemble models calls for caution in interpreting the high-performance levels reported, as these may reflect overfitting or limited capacity for generalization, while the recurrent exclusion of socioeconomic, personal, and contextual variables constrains the explanatory power of the models and their applicability for designing comprehensive interventions. Moreover, the substantial methodological heterogeneity of the studies, the frequent use of secondary data, and the concentration of evidence in specific contexts limit the transferability of the findings and highlight the need for future comparative, longitudinal, and context-sensitive research.

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TEACHING WITH TECHNOLOGY: LECTURER CHALLENGES IN ADOPTING AI TOOLS FOR STEM

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Abstract

This paper examines the challenges lecturers face when adopting Artificial Intelligence (AI) tools in STEM teaching at a South African private higher education institution. Using qualitative secondary analysis of interview, observation, and focus group data from a Master's study, the research re-analyses lecturers' experiences through Rogers' Diffusion of Innovation (DOI) theory. The findings identify key interrelated barriers, including student misuse, unreliable infrastructure, coding inaccuracies, academic integrity concerns, limited training, cautious lecturer attitudes, and increased workload. These challenges map onto DOI attributes, relative advantage, compatibility, complexity, trialability, and observability, highlighting that AI adoption is shaped primarily by systemic and institutional conditions rather than individual resistance. The study argues that sustainable AI integration in STEM requires reliable infrastructure, discipline-specific professional development, and clear ethical guidance, and offers contextually relevant recommendations for higher education.

Keywords: *Artificial intelligence, STEM education, diffusion of innovation, higher education, lecturer adoption.*

1. Introduction

The integration of Artificial Intelligence (AI) in higher education has accelerated due to its potential to enhance teaching through adaptability and efficiency. Within STEM education, AI is increasingly recognised as transformative, influencing both instructional design and student engagement (Xu & Ouyang, 2022; Ajayi, 2024).

Despite these opportunities, significant challenges remain. Concerns relating to data privacy, unequal access, and ethical use continue to shape AI adoption, alongside limited AI literacy among lecturers and students (Mahmud et al., 2024; Mah & Groß, 2024). Research indicates that adoption is influenced not only by individual perceptions but also by institutional conditions and social context (Perez, 2024).

In the South African context, digital transformation accelerated during the COVID-19 pandemic, exposing both opportunities and structural inequalities (Mhlanga et al., 2022). Ongoing challenges, including unreliable infrastructure and uneven professional development, continue to constrain the adoption of advanced technologies such as AI (Msila, 2022; Teane & Matlala, 2025). These conditions are further shaped by broader transformation imperatives, including responsiveness to the Fourth Industrial Revolution and decolonisation agendas (Turner, 2023; Samuels & Singh, 2025).

Against this backdrop, this study examines the barriers lecturers experience when adopting AI tools in STEM teaching within South African higher education. The research question guiding the study is: What barriers and challenges do lecturers face when adopting AI tools in STEM teaching within South African higher education?

The objectives are to:

1. Re-analyse lecturers' experiences of AI integration using existing qualitative data.
2. Interpret these challenges through Rogers' Diffusion of Innovation theory; and
3. Generate contextually relevant recommendations for ethical and sustainable AI adoption.

2. Literature review

The adoption of emerging technologies in higher education is commonly examined through frameworks that explain how innovations are accepted or resisted. Rogers' Diffusion of Innovation (DOI) theory is widely used to understand technology uptake within educational contexts, conceptualising adoption as a socially influenced process shaped by the perceived attributes of an innovation and the institutional environment in which it is implemented (Rogers, 2003; Currie et al., 2021).

In higher education, research shows that successful technology adoption depends not only on individual willingness but also on enabling institutional conditions such as leadership support, infrastructure, and professional development. Adoption is often non-linear and may be constrained by workload pressures, skill gaps, and concerns about pedagogical control (Buč & Divjak, 2015; Gonçalves & Pedro, 2012). These insights position DOI as a useful lens for examining AI adoption, which introduces both opportunity and uncertainty in teaching practice.

While alternative models such as the Unified Theory of Acceptance and Use of Technology (UTAUT) emphasise individual-level determinants, including perceived usefulness and ease of use (Venkatesh et al., 2003), DOI offers a broader perspective by capturing the interaction between institutional, pedagogical, and social factors.

Recent literature highlights both the potential and challenges of AI adoption in higher education. AI tools are associated with personalised learning and automated support, particularly in STEM contexts (Xu & Ouyang, 2022; Ajayi, 2024). However, adoption is constrained by infrastructural limitations, limited resources, and unresolved ethical concerns, including academic integrity and data privacy (Mah & Groß, 2024; Ojha, 2024).

Within the South African context, AI adoption reflects both innovation and inequality. While digital transformation has accelerated, adoption remains uneven due to infrastructural constraints, digital divides, and variable institutional support (Mhlanga et al., 2022; Funda & Mbangeleli, 2024). These conditions highlight the need for systemic approaches that extend beyond individual acceptance to include institutional readiness and contextual alignment.

Overall, the literature indicates that AI adoption in higher education is shaped by the interaction of individual perceptions, institutional conditions, and broader socio-cultural factors. DOI provides a suitable framework for examining how these dimensions converge to influence the adoption of AI tools in STEM teaching.

3. Theoretical framework

This study is underpinned by Rogers' Diffusion of Innovation (DOI) theory, which explains how new technologies are adopted within social and institutional contexts (Rogers, 2003). In higher education, DOI provides a useful lens for examining how lecturers engage with emerging technologies such as AI.

The theory identifies five attributes that influence adoption: relative advantage, compatibility, complexity, trialability, and observability. In the context of AI in STEM teaching, these attributes shape how lecturers evaluate the usefulness, alignment, and practicality of AI tools in their pedagogical practices.

This study applies DOI to examine how institutional, technical, and pedagogical factors influence lecturers' adoption of AI. Rather than treating adoption as a binary outcome, the framework enables analysis of how systemic conditions and individual perceptions interact to shape uptake.

DOI has been widely applied in educational contexts to analyse technology adoption in digitally transforming environments (Mbatha, 2024; Alka'awneh et al., 2025). Its focus on both organisational and social dynamics makes it particularly appropriate for examining the barriers to AI adoption in STEM teaching.

4. Methodology

This study employed a qualitative secondary analysis of data originally collected for a Master's study examining AI adoption in first-year STEM teaching at a South African private higher education institution (Govender, 2025). The analysis focused specifically on lecturers' experiences of challenges and barriers to AI adoption.

The dataset comprised semi-structured interviews, classroom observations, and a focus group involving five STEM lecturers with experience using AI tools in teaching. Data were transcribed, anonymised, and re-analysed using Rogers' Diffusion of Innovation (DOI) theory as the primary analytical framework.

The analysis was conducted using ATLAS.ti, with codes explicitly mapped to DOI attributes: relative advantage, compatibility, complexity, trialability, and observability.

Credibility was enhanced through triangulation across data sources and consistent pattern identification.

4.1. Ethical considerations

Informed consent obtained in the original study explicitly permitted future academic use of anonymised data. The present analysis was therefore conducted within the scope of those ethical approvals.

5. Findings

This section presents the key challenges lecturers experienced when adopting AI tools in STEM teaching at a South African private higher education institution. Based on a secondary analysis of interviews, classroom observations, and a focus group discussion, eight themes were identified and mapped to Rogers' DOI attributes. Table 1 summarises the themes, supporting quotations, and associated DOI constructs. Overall, lecturers reported persistent challenges related to student misuse of AI tools, unreliable technical infrastructure, inaccuracies in AI-generated content, limited institutional support, academic integrity concerns, and increased workload. These challenges influenced lecturers' confidence, willingness to experiment, and perceptions of AI's pedagogical value.

Student misuse of AI tools emerged as a compatibility concern, with lecturers noting that students often relied on AI outputs without critical engagement. Technical infrastructure limitations constrained opportunities for experimentation, reducing trialability and increasing perceived complexity.

Concerns regarding coding inaccuracies and the need for constant verification undermined the perceived relative advantage of AI use.

Lecturers further highlighted limited training and institutional guidance, which affected both compatibility and trialability. Cautious lecturer attitudes reflected uncertainty about the pedagogical implications of AI, particularly in relation to academic integrity. Finally, increased workload and time pressures diminished perceptions of efficiency, further limiting adoption.

Table 1. Summary of key themes and DOI alignment.

Theme	Description (Condensed)	DOI Attribute(s)
Student misuse of AI	Reliance on AI outputs without critical engagement	Compatibility
Technical infrastructure	Unreliable connectivity limits classroom use	Trialability, Complexity
Verification of AI output	Need to check and refine AI-generated content	Relative Advantage
Coding inaccuracies	Errors and outdated outputs increase difficulty	Complexity
Training and support gaps	Limited institutional guidance and professional development	Compatibility, Trialability
Lecturer attitudes	Cautious adoption due to pedagogical concerns	Compatibility, Relative Advantage
Academic integrity concerns	Plagiarism and superficial learning challenges	Observability
Workload pressures	Increased effort to manage and verify AI use	Relative Advantage

6. Limitations

As a secondary analysis, this study was limited to one thematic focus, challenges and barriers to AI adoption, from a broader dataset. The participant group was relatively small (five STEM lecturers from a single private higher education institution), which limits generalisability to other contexts. The findings should therefore be interpreted as contextually rich insights rather than universal conclusions.

7. Discussion

The findings indicate that while STEM lecturers recognise the potential pedagogical value of AI tools, adoption is constrained by systemic and pedagogical barriers. Interpreted through Rogers' DOI theory, these challenges reflect limited alignment with key innovation attributes, which collectively slow the diffusion of AI in higher education.

The perceived relative advantage of AI was undermined by increased workload pressures, particularly the need to verify and correct AI-generated outputs. Rather than enhancing efficiency, AI often introduced hidden labour, reducing its perceived benefit. However, where lecturers reframed AI outputs as learning artefacts for critique and discussion, relative advantage became more visible, suggesting that pedagogically informed integration can offset efficiency concerns.

Compatibility challenges were evident in student misuse of AI as an answer-providing shortcut, which conflicted with lecturers' goals of fostering critical thinking and academic integrity. These tensions

shaped cautious lecturer attitudes and selective adoption practices, reinforcing the importance of aligning AI use with established pedagogical values and ethical expectations.

Complexity further constrained adoption, especially in coding-intensive STEM contexts where inaccurate or outdated AI outputs increased the learning curve for both lecturers and students. Without targeted training and institutional support, these technical limitations heightened uncertainty and reduced confidence in AI use.

Trialability was limited by unreliable infrastructure and the absence of low-risk opportunities for experimentation. In line with DOI theory, restricted trial environments discouraged lecturers from investing time in exploring AI tools. Observability was similarly constrained, as lecturers struggled to determine whether AI use resulted in meaningful learning or superficial engagement. Although some educators addressed this through redesigned, critique-based assessments, the benefits of AI often remained difficult to demonstrate.

Taken together, these findings highlight that barriers to AI adoption in STEM teaching are not isolated technical issues but are embedded within broader institutional and pedagogical systems. DOI theory illustrates how deficiencies across multiple innovation attributes converge to impede diffusion. Addressing these challenges requires systemic interventions, including reliable infrastructure, discipline-specific professional development, and clear ethical frameworks to support sustainable and meaningful AI integration.

8. Recommendations

Based on the findings and informed by Rogers' DOI theory, the following recommendations are proposed to support effective and ethical integration of AI tools in STEM teaching within South African higher education.

First, institutions should enhance the relative advantage of AI by supporting pedagogically purposeful uses that reduce, rather than increase, lecturer workload. This includes professional development focused on AI-integrated lesson design and assessment practices where AI demonstrably improves efficiency, such as formative feedback and personalised learning support.

Second, AI adoption should be strengthened through improved compatibility and reduced complexity. Structured faculty development should extend beyond tool familiarisation to include ethical AI use, discipline-specific applications, and strategies to discourage superficial student reliance on AI outputs. Targeted support, particularly in coding-intensive STEM contexts, can build lecturer confidence and lower perceived barriers to use.

Third, institutions should improve trialability and observability by creating supportive environments for experimentation and knowledge sharing. Providing reliable digital infrastructure, low-risk pilot spaces, and communities of practice can enable lecturers to test AI tools safely and make successful practices more visible, thereby accelerating diffusion.

Collectively, these recommendations emphasise that meaningful AI adoption depends not only on technological access but on institutional readiness, pedagogical alignment, and ethical governance. By addressing key DOI attributes, higher education institutions can position AI as a catalyst for reflective and contextually relevant innovation rather than a source of uncertainty.

9. Conclusion

This study examined the challenges lecturers face when adopting AI tools in STEM teaching within a South African private higher education institution. Through a secondary analysis of interviews, focus groups, and classroom observations, key barriers were identified, including student misuse, infrastructural limitations, coding inaccuracies, academic integrity concerns, and limited institutional support. Interpreted through Rogers' Diffusion of Innovation theory, these barriers mapped onto limited relative advantage, poor compatibility, high complexity, restricted trialability, and weak observability.

The analysis demonstrates that AI adoption is not hindered by technological availability alone but by systemic, pedagogical, and institutional conditions. Addressing these challenges requires enhancing the perceived value of AI, ensuring alignment with curriculum goals, reducing complexity through training, enabling experimentation, and making successes more visible.

By grounding recommendations in DOI theory, this paper highlights the need for strategic, evidence-based interventions to ensure that AI integration is ethical, sustainable, and contextually meaningful in South African higher education. Ultimately, diffusion of AI in STEM will depend on institutions' ability to align technological possibilities with human capacities, pedagogical integrity, and the broader transformation goals of higher education.

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THE TEACHER AS A CONSOLIDATING FACTOR IN THE CONTEMPORARY BULGARIAN DIASPORA

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Abstract

The Bulgarian legislative system establishes teachers as a key factor in shaping individuals. Additional requirements for their training and qualifications are also specified, with certain pedagogical skills being required in addition to basic training. The development of education in the Bulgarian diaspora provides an interesting example of the role of teachers in society. This concerns the formation and development of the contemporary (new) Bulgarian diaspora, whose profile shows different motivations for leaving their homeland, as well as additional intentions to return in the future. Of interest is the reception of teachers among the Bulgarian diaspora in Cyprus, where, in addition to their didactic functions, teachers—as the examples show—prove to be key factors for inter-dialogue (community-host country), for maintaining identity through continuous participation in systems of ongoing qualification (the country of origin), as well as through involvement in additional organizational tasks. Since schools abroad, like those in Cyprus, are designated as Saturday-Sunday schools, the principals are also teachers at the school, mainly in the humanities. At the same time, they also have an additional profession, depending on the situation in the host country. Thus, schools abroad are run by a teacher who, in addition to organizing the educational process – attracting students, developing curricula, selecting additional teachers, ensuring contact with the responsible institutions in Bulgaria – also acts as a key figure in the Bulgarian community, who performs the main tasks for its consolidation.

Keywords: *Contemporary emigration, new emigration, teacher, Saturday-Sunday schools, identity, holidays*.

1. Introduction

The Bulgarian legislative system (Law on Pre-school and School Education) establishes the regulatory requirements for teacher training and professional qualification. Persons with higher education in the relevant specialty and with mandatory pedagogical qualification are appointed to the position of "teacher" (https://www.lex.bg). In a special section entitled "Improving the qualifications of teachers, principals, and other educational specialists," the ZPUO sets out the principles governing the qualification process. According to the legal texts, qualification is a continuous process that is organized and conducted by higher education institutions according to programs prepared by them. Its purpose is to support the improvement and updating of the knowledge and skills of teachers and other educational specialists and to provide them with modern approaches and teaching methods. Higher education institutions issue a document (diploma) certifying the level of professional qualification obtained.

On the other hand, Regulation No. 15 of 2019 introduces the state standard for the professional development of teachers, principals, and other educational specialists. The state standard specifically outlines the basic requirements for the position of "teacher": *planning, organizing, and conducting the educational process; applying effective educational methods and approaches in line with the individual needs of children and students; effective use of digital technologies; assessing the progress of children and students in acquiring key competences; analyzing the educational results and competencies developed by children and students; providing general and additional support for the personal development of children and students for their full inclusion in the educational and social environment; cooperating and interacting with participants in the educational process and all interested parties; participation in the conduct of national external assessment, state matriculation examinations, compulsory state examinations, or state examinations for the acquisition of professional qualifications and/or the acquisition of legal capacity for professions whose practice requires such qualifications; preparation of examination materials for assessing the knowledge and skills of students in the relevant subject or module; career guidance and counseling for students; development and implementation of projects and programs; participation in*

professional mobility and professional communities; developing and implementing strategic documents related to the institution's activities; protecting the life and health of children and students, including during organized extracurricular activities or interest groups; maintaining and storing mandatory documents; conducting consultations with students and parents; creating a school culture oriented towards tolerance, cooperation, and mutual assistance; conducting or participating in research activities in the field of preschool and school education. (Regulation No. 15 of 2019, https://lex.bg/)

As can be seen, the normative texts relating to the job characteristics of teachers in Bulgarian legislation present them as key figures, endowed with the tasks of educating and preparing students, but also with the implementation of a number of organizational goals. In this regard, and as practice shows, teachers are presented as an essential socialising factor – it is well known that the atmosphere in the classroom depends on their skills and competences. On the other hand, the public authority of teachers testifies not only to their personal abilities and qualities, but also to the degree of maturity of society and the formation of sustainable ethical values.

The law also provides for the establishment and development of Bulgarian schools abroad, known as Sunday schools. The initiative for their creation is left to civil society organizations of Bulgarian communities abroad.

Decree No. 90 of the Council of Ministers on Bulgarian Sunday schools (adopted in 2018 and supplemented in 2022) regulates the status of Sunday schools, specifies the commitments of the state, and sets out the requirements for teachers in schools abroad. Article 1, paragraph 1 states that the Bulgarian state shall provide funds from the national budget to support the teaching of Bulgarian language and literature, Bulgarian history and civilization, Bulgarian geography and economics – subjects that preserve and develop national identity. Other issues relating to the activities of Sunday schools and their primary role in preserving and developing the ethno-cultural identity of Bulgarians abroad are also regulated.

The Decree introduces the legal provision that the requirements for holding the position of "teacher" in Bulgaria also apply to holding the position of "teacher" in Bulgarian schools abroad: the teacher carries out educational activities, but at the same time, his or her priority task is to fulfill his or her public commitments in relation to the processes of preserving and developing identity.

The legislative framework gives teachers in Sunday schools abroad the freedom, opportunities, and prospects to expand the scope of their immediate tasks, to support students in their efforts to master the Bulgarian language, Bulgarian history, Bulgarian geography in a foreign environment, and to understand and assimilate the moral and aesthetic values and traditions of both their country of birth (Bulgaria) and their host country. In this way, from the point of view of the normative documents, the teacher emerges as an important factor both in the development of the individual, especially in terms of their ethnocultural identity, and as a driving force in the processes of consolidation and cultural elevation of the Bulgarian diaspora (Decree No. 90 / /https://www.lex.bg).

Decree No. 90 also stipulates that every newly established Sunday school must be entered in a register at the Bulgarian Ministry of Education and Science. A review of this register confirms the upward trend in their number, which, on the one hand, testifies to their paramount importance for the development and consolidation of every Bulgarian community abroad. On the other hand, it also indicates the increased demands on teachers and their ability to unite the community both horizontally and vertically.

In a study on the history of Bulgarian Sunday schools abroad, Boyan Kulov highlights the quantitative growth of Sunday schools abroad and formulates the creation of a new phenomenon: *about 10% of schools that teach Bulgarian language, history, geography, and culture are located outside its borders and are spread across all continents with permanent populations* (Kulov, 2016). It turns out that Sunday schools contribute not only to the preservation and development of Bulgarian identity, but also, indirectly, testify to the formation of the Bulgarian diaspora, the settlement of migrants, and their adaptability in the host country.

2. Sunday school traditions

The historical traditions of Sunday schools date back to the era of Ottoman rule. Sunday schools were established in churches and monasteries with the aim of providing students with basic literacy and skills in simple mathematical operations—addition and subtraction. As for the teachers, they were clergymen and there were no special requirements for their training other than the necessary religious knowledge. In the first decades of the 19th century, when the first secular school was opened in Gabrovo (1835), the clergy, who also served as teachers, possessed more competence, took an interest in secular knowledge, and systematized it in textbooks and teaching aids for the needs of Bulgarian secular education.

With the development of secular education, more and more secular figures who had received their education at renowned schools in Istanbul or abroad were appointed as teachers. It is striking that teachers from this period were distinguished by their high level of humanities education – they spoke languages,

were familiar with classical and modern literary works, but were also interested in the natural sciences. Since the Bulgarian Renaissance period is associated with the development of modern Bulgarian culture, teachers became the driving force behind new ideas, stimulating the organization of the people's energy into a unified whole.

On the other hand, the period of Ottoman rule was also a time of the first mass migrations of Bulgarians and their settlement in other countries. When settling in the host country, as researchers point out, the first institution they introduced was the school as a defining sign of identity. The teachers in these schools were also immigrants from Bulgaria, but over time, teachers who had graduated from renowned schools in the host country or abroad were also appointed. In addition to teaching, teachers in these schools in the diaspora write and publish textbooks and teaching aids, create poems and works of fiction, and translate into their native language. Significantly, these literary and creative texts are distributed in Bulgarian territories. After the Liberation of Bulgaria in 1878, a large part of the graduates of these schools, as well as their teachers, returned to Bulgaria and participated in the building of the new state.

Therefore, from the very beginning of its establishment, the Bulgarian diaspora identified itself as independent, creating a school where the native language was taught above all else. In turn, teachers took on various tasks—educational, but also cultural and social. They contributed to the preservation and development of cultural memory. But teachers were also the driving force behind the consolidation and modernization of society. Thanks to teachers, contacts with other ethnic groups and other civilizations and cultural spaces intensified. A careful reading of the biographies of Bulgarian teachers who worked in schools of the Bulgarian diaspora during that period shows that most of them (like those living in Bulgarian lands), in addition to teaching, were involved in large-scale cultural activities – they were revolutionaries, thinkers, writers.

That is why teachers during the Bulgarian Renaissance were regarded as important cultural figures, endowed with the additional significance of spiritual guides and leaders, and bearers of the understanding of heroism and self-sacrifice in the name of national dignity and honor. It is no coincidence that decades after the Liberation, in 1922, the then Bulgarian Minister of Education, Stoyan Omarchevski, introduced the holiday "National Revivalists," dedicated to the spiritual leaders of the nation, the majority of whom were teachers.

Therefore, it is traditional in Bulgarian culture for teachers to perform a variety of cultural roles, to be bearers of high knowledge and competence, but also people with high morals and social commitment.

3. Bulgarian emigration in the 20th century and the development of schools abroad

Researchers studying Bulgarian emigration point out that in the 20th century, Bulgarian migrants settled in Central and Eastern European countries, as well as in North and South America (Borisova et al., 2017). In Hungary, for example, Bulgarian emigrants established their own organization, the Society of Bulgarians in Hungary, which in 1918 founded the Hristo Botev Bulgarian school in Budapest (100 Years of Bulgarian School // https://frognews.bg/obshtestvo/minalo/100-godini-balgarsko-uchilishte-budapeshta.html).

On the other hand, in North America (Canada and the US), in just three decades (1908-1940), Bulgarians opened dozens of schools, equal in number to the newly established church institutions (Kulov, 2016). The teachers were Bulgarians, part of the diaspora, and their task, as in the previous period, was to provide education in their native language. In addition to their educational activities, teachers devoted themselves to cultural initiatives—publishing newspapers, helping Bulgarian immigrants integrate into their new environment, contributing to the cultural advancement of the community, etc.

In the second half of the 20th century, state schools were also established abroad, in Budapest and Bratislava, areas with a high concentration of Bulgarian immigrants. The practice was to send teachers of the native language from Bulgaria to support the efforts of the diaspora to preserve and develop Bulgarian ethnic and cultural identity. The teachers sent were highly educated, some of them poets, fiction writers, and publicists.

Therefore, the establishment and development of Bulgarian schools abroad and the assignment of cultural tasks to teachers in these schools has become a tradition that is supported by Bulgarian diaspora organizations in their respective countries of residence, and in the second half of the 20th century, with the partial participation of the Bulgarian state.

A new stage in the development of Bulgarian schools abroad began in the second decade of the 21st century, when Bulgaria started subsidizing the teaching of Bulgarian language, history, and geography in Sunday schools. In 2024, there were 396 Bulgarian Sunday schools around the world, located in 42 countries (Ivanov, 2024). These Sunday schools were established as a result of a civic initiative in places with a relatively large community of Bulgarian emigrants, whose children attend both the schools of the host country and, at the end of the week, Bulgarian Sunday schools.

The expansion of the network of Sunday schools requires the provision of teaching staff to take on the education of students in a foreign environment. For several years now, through the Ministry of Education and Culture, universities have been organizing programs for pedagogical qualification and continuing education for teachers in Bulgarian Sunday schools abroad. The diaspora is responsible for organizing candidates for teachers in Bulgaria who will be prepared for teaching in schools abroad.

4. The educational and cultural role of teachers in the Bulgarian diaspora in Cyprus

According to a number of theoretical observations, migrants, including teachers, are bearers of their own identity (ethnocultural), but also acquire an additional one – that of the host country. This is why researchers talk about transmigrants (Shiller et al, 1992: 1-24), who are characterized by multiple identities: identity by birth and identity acquired from the country of residence. In her study "The Island of Aphrodite – 'Home' for Many Bulgarians," Yelis Erolova emphasizes that this type of transmigrant is characteristic of Cyprus and is due to a variety of factors. Among the transmigrants, the researcher also mentions teachers who come to Cyprus either through mixed marriages or economic migration, etc. (Erolova, 2013).

Bulgarian Sunday schools in Cyprus have similar characteristics to other Bulgarian Sunday schools around the world. The representative organisations of Bulgarians in Cyprus include teachers from Bulgarian schools in their management structure, with teachers also being assigned the responsibility of school principals.

The principal of the largest Bulgarian school in Cyprus, Nikola Vaptsarov School in Nicosia, Ms. Lidia Stefanova, is a geography and economics teacher. Ms. Stefanova is an active member of the Union of Bulgarians in Cyprus and one of the founders of the school. In addition to the principal, the school's team includes nine teachers: Bulgarian language and literature, Bulgarian history, Bulgarian geography and economics, choir singing, and folk dancing. All teachers have a university degree in the subject they teach and the necessary teaching qualifications, acquired in Bulgaria.

In addition to Bulgarian, a prerequisite for practicing the profession of teacher in Bulgarian Sunday schools is proficiency in Greek, and knowledge of a Western language, most often English, is desirable. Teachers offer extracurricular activities such as folk dancing, singing, creative and art activities. Assistance with preparing lessons for Cypriot schools is also offered. Additional Greek, English, and Russian language classes are organized, which are also attended by adult migrants, some of whom are mobile migrants. Thus, teachers work with students of different age groups – from the youngest (preschool groups) to their parents, who assist in the process of their adaptation.

In parallel with the programme approved by the Bulgarian Ministry of Education and Science, teachers are developing additional lesson plans focusing on the cultural links between Cypriot and Bulgarian traditions and values: family values, historical contacts between Bulgaria and Cyprus, links between the Cypriot and Bulgarian Orthodox Churches, etc. This supports the development of cultural dialogue and interaction.The teachers, led by their principal, actively develop international cooperation. Together with their students, they participate in festivals and festive parades, initiate meetings with guests from Bulgaria and abroad on national and international cultural topics (BU "N. Vaptsarov" // https://www.bgschoolnicosia.com/).

Another director of a Bulgarian school in Cyprus is Ms. Zhivka Milova. Four other teachers work at the Narodni Buditeli School, located in Paralimni, Famagusta. (https://www.bgschoolparalimni.com/). Ms. Milova graduated with a degree in history in Bulgaria and also holds two master's degrees in education and management. In addition to being a principal and teacher, Ms. Milova is the vice-chair of the Bulgarian Cultural Association in Cyprus, an organization of Bulgarian immigrants who have settled in the Famagusta district. Teachers regularly participate in continuing education courses organized by the Bulgarian state, improving their skills and competencies for working with students in a foreign environment.

Field studies conducted in September 2025 provide grounds for the observation that teachers in schools abroad should be regarded as key cultural figures who, in addition to their educational role, also play a significant socializing role in the diaspora and in the host society. In their managerial role as school principals, teachers organize the educational process. For example, Ms Milova is a teacher of Bulgarian history and civilisation, teaching the programmes approved by the Bulgarian Ministry of Education and Science for this subject. At the same time, however, her students attend Cypriot schools, and some of them are children from mixed marriages. With a view to promoting intercultural dialogue, Ms Milova introduced an additional study of the diachronic contact zones between Cyprus and Bulgaria, using the possibilities offered by modern technologies. As a result of the educational activity with her support, the students create a documentary film about the secrets of Famagusta, the hidden history of Cyprus, and the Bulgarian traces from the past and present, which wins prestigious international awards. Therefore, the teacher takes on the role of driving the trilateral dialogue: community - Bulgarian state - host state.

Another characteristic feature of teachers is that, in addition to their educational and cultural tasks, they also pursue important social goals. The example of Ms Milova is indicative. As a representative of the diaspora, she is the author of journalistic articles, analyses and commentaries on Cypriot culture, and works as a regular correspondent for Cyprus for the Bulgarian Telegraph Agency. These publications establish an important link with her country of birth, present the achievements of the diaspora in Cyprus, and support Bulgaria's state education policy towards Bulgarians abroad by highlighting unresolved problems and emerging issues.

Previous studies on the educational situation in Bulgarian schools in Cyprus (Erolova, 2013) have highlighted an interesting fact: unlike the educational situation in Bulgaria, mobile migrants of Roma origin enrol their children en masse in Sunday schools and they successfully complete the relevant educational levels. This issue is still subject to further in-depth research.

5. Conclusion

The focus on the role of teachers in schools abroad is not accidental. It illustrates – in a categorical way – the historical and cultural continuity with ideas and trends related to the public perception of the role of Bulgarian teachers (especially from the era of the Bulgarian Renaissance). On the other hand, it turns out that, in addition to their educational tasks, teachers are also burdened with the mission of implementing the cultural programs of the diaspora: they are responsible for preserving and transmitting national cultural memory, and for developing skills for constructive dialogue within and outside the community, as studies on the role of teachers in the contemporary Bulgarian diaspora in Cyprus convincingly show.

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HYPER-REALISTIC AVATARS IN EDUCATION: A SYSTEMATIC REVIEW FOR HYPER-REALISTIC AVATAR DESIGN IN EDUCATION

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Abstract

Instructor presence remains a widely researched topic in pedagogy, yet findings are mixed across studies that examine both human instructors and human-like virtual avatars. In videos featuring human instructors, several analyses report no reliable gains in learning and, in some cases, heightened cognitive load, although learner motivation tends to increase (Alemdag, 2022). By contrast, research on virtual instructors indicates modest benefits: across multimedia settings, pedagogical agents are associated with minor average improvements in learning (Castro-Alonso, 2021). In immersive virtual reality, human-like avatars have been shown to enhance retention, transfer, and social presence, with cognitive load largely unchanged (Zhang, 2025). Even within a single medium, however, effects can vary considerably. A key gap concerns the extent to which results generalize between studies of human instructor presence and studies of virtual avatars. As hyper-realistic avatar creation platforms become increasingly accessible, bridging this gap is essential to determine how insights from both literatures can inform the design of educational content. This study presents an umbrella synthesis of existing reviews spanning instructor types (human and virtual), delivery platforms (image, video, and virtual reality), stylistic features (talking head and full body), and instructional roles (instructional tutor, mentor, and demonstrator). It provides a comprehensive synthesis of the pedagogical and cognitive theories pertinent to evaluating instructor presence, together with a review of the evaluation methodologies employed in the literature. Practical recommendations are offered on when and how to include instructors across modalities for educators and instructional designers. Finally, the study identifies gaps in the evidence base to motivate future research in this field.

Keywords: *Educational avatars, pedagogical agents, generative artificial intelligence, educational videos, virtual reality.*

1. Introduction

Instructor presence, defined as the perceptible involvement of an instructor in a learning environment, is widely recognized as a key factor in effective education. Across disciplines, researchers have examined how an instructor's visible or perceptual presence influences student engagement and learning. In the context of online and blended education, this concept intersects with learning sciences, educational psychology, and instructional design through theories of social interaction and guidance in learning. It also extends into multimedia learning research on video-based instruction and into Human-Computer Interaction (HCI) in education where virtual tutors and avatars are designed to emulate human teaching behaviors. The interdisciplinary nature of instructor presence is evident: it encompasses both the teaching role (structuring content and providing feedback) and the social role (connecting with learners). Understanding how to optimize instructor presence is thus a concern for those designing e-learning experiences, studying cognitive and motivational processes, and developing emerging AI-driven educational agents.

This paper aims to address the following research questions through an umbrella synthesis of systematic literature surveys in human and virtual instructor research:

1) Which pedagogical and psychological theories are used to assess the effectiveness of human and virtual instructors in the literature?
2) Which methodologies and evaluation frameworks are used to assess the effectiveness of human and virtual instructors in the literature?
3) What recommendations can be synthesised for instructional designers using hyper-realistic avatars as instructors?

The paper is organised as follows; Section 2 provides background information about human and virtual instructor research, and the new gap created by hyper-realistic avatar platforms; Section 3 outlines the umbrella synthesis methodology used in this study; Section 4 discusses the shortlisted reviews and their coverage of the area, while Section 5 synthesises the findings into recommendations and Section 6 offers some concluding remarks and future directions.

2. Background

2.1. Human instructor presence in multimedia learning

One thread of research has focused on human instructors in video and online course contexts. A debate has emerged on whether showing the instructor's face or image in instructional videos improves learning outcomes or merely adds extraneous information. Empirical findings in the past decade have been mixed and sometimes contradictory (Alemdag, 2022; Polat, 2023). On one hand, some studies report that learning from videos with a visible instructor is more effective or engaging than from videos with voiceover alone. For example, certain experiments found higher student performance and satisfaction when the instructor appeared on-screen, suggesting that gestures, eye contact, and other social cues can foster engagement. On the other hand, other studies have found little to no learning benefit, or even noted that an on-screen teacher might distract learners from the content (Polat, 2023). This heterogeneity in results has prompted meta-analytic investigations to identify general trends. Recent evidence indicates that instructor presence yields nuanced effects: including a lecturer's image in videos produces small but significant gains in factual retention of material, yet does not reliably improve deeper transfer learning Notably, however, having the instructor visible tends to enhance learners' subjective experience - increasing their reported social presence, interest, and motivation (Beege et al., 2023) Intriguingly, this social benefit may even extend to cognitive processing: contrary to what a strict cognitive load perspective might predict, seeing the instructor can reduce students' perceived extraneous cognitive load in some cases (Beege et al., 2023). In other words, an on-screen instructor might make students feel more guided and at ease, offsetting potential visual processing costs. These findings illustrate that human instructor presence can have positive affective and cognitive effects, but its impact on measurable learning performance remains context-dependent.

2.2. Virtual instructors and digital pedagogical agents

Parallel to the work on human instructors in videos, an extensive body of research in educational technology and HCI has explored virtual instructors - including animated pedagogical agents on computer screens and avatars in virtual or augmented reality. These digital "instructors" serve a similar purpose of providing guidance and social interaction cues in the absence of a live teacher. Like their human counterparts, virtual agents have yielded heterogeneous findings in the literature. Many studies (across domains like educational psychology and AI in Education) have shown that pedagogical agents can enhance learners' motivation, engagement, and even academic performance by leveraging the so-called "persona effect" - the idea that students respond socially to on-screen characters (Li et al., 2025). For instance, an agent that gestures and converses in a friendly manner may increase learners' interest and effort. Other researchers have raised concerns that adding a talking avatar or cartoon tutor might impose extra cognitive processing demands. According to some cognitive load theorists, a graphical agent could act as a distractor, forcing learners to split attention between the agent and the instructional content, thereby increasing mental load or creating interference (Li et al., 2025). Indeed, the empirical results on this issue have been far from uniform. A recent meta-analysis (Li et al., 2025) synthesized a decade of studies and identified three divergent positions: some experiments find that pedagogical agents reduce students' cognitive load (by focusing attention or providing support), others find that agents increase cognitive load (by introducing extraneous visual information), and many find no significant difference at all. Similarly, while some implementations of virtual tutors lead to better learning outcomes or stronger feelings of social presence, other implementations show negligible effects. In sum, the pedagogical impact of virtual instructor agents appears highly contingent on design features and context. This inconsistency mirrors the conflicting findings with human instructors in videos, suggesting a need for a broader synthesis to understand under what conditions an instructor's presence - whether human or virtual - truly benefits learning.

2.3. Hyper-Realistic avatars and need for a cross-medium review

Historically, research on traditional online video instruction and research on virtual/AI instructors have often progressed in separate silos. Reviews note that pedagogical agent studies rarely extended into fully immersive VR until recently, meaning insights from one medium have not readily translated to the other. With the rapid convergence of these domains (e.g., instructors on camera, animated tutors on desktops, and VR avatars coexisting in today's educational landscape), it is crucial to integrate lessons

learned across modalities. The present umbrella review is motivated by this gap. By comparing human instructors and virtual agents/avatars side by side, we seek to reconcile the conflicting findings regarding learning outcomes, cognitive load, motivation, and social presence across the two strands of research.

3. Methodology

We conducted an umbrella review (an overview of reviews), following PRISMA (Page et al., 2021) search practices. Searches were run in ERIC, SCOPUS, and IEEE Xplore to identify systematic reviews and meta-analyses on instructor presence in learning contexts. The search terms were filtered to systematic reviews that investigated the use of human or virtual instructors in any medium, specifically in an educational context. Only articles published in English between 2022 and 2025 were included to narrow the scope to reviews from the period when hyper-realistic avatar creation platforms became more accessible, while recognising that the reviews may also include source studies published before this time frame.

Titles/abstracts and full texts were screened against predefined criteria. Of 53 search results, 20 reviews passed the initial title/abstract screening, and 8 passed the full-text screening for inclusion in this synthesis. Data were extracted at the review level using a structured form aligned to the paper's organizing framework: instructor type (human vs virtual), platform (image, video, VR), stylistic features (talking head vs full body), as reported in Section 4.

4. Results

Eight systematic reviews were synthesised for this study, shown in Table 1. They included a mix of human and virtual instructor studies across different forms of media, including video, VR, multimedia and blended learning settings. Only studies investigating instructional (educational) settings were considered.

Table 1. Selected reviews for synthesis.

Author	**Instructor**	**Medium**	**Style**
Beege et al., 2023	Human	Video	Talking head / Torso
Polat, 2023	Human	Video	Talking head / Torso
Stap et al., 2024	Human	Blended Learning	Not specified/controlled
T. Liu, 2025	Virtual	Multimedia	Animated/Embodied characters
Wang et al., 2023	Virtual	Multimedia	Talking head / Torso
Zhang & Pan, 2025	Virtual	VR	Animated/Embodied characters
Q. Zhang & Yu, 2023	Human	Video	Talking head / Torso
Zhu et al., 2024	Human	Video	Talking head / Torso

5. Discussion

5.1. Pedagogical theory considerations

Cognitive Load Theory (CLT) is often employed as one of the main critical frameworks in instructor presence research (Beege et al., 2023; Stap et al., 2024; Q. Zhang & Yu, 2023), establishing a baseline that instructor presence might impose extraneous load, but the consensus is that affective elements can mitigate this. The Cognitive-Affective Theory of Learning with Media (CATLM) posits that social cues from instructors can increase emotional engagement, reducing cognitive load and increasing motivation (Beege et al., 2023; Polat, 2023; Wang et al., 2023; Zhu et al., 2024). Similarly, Social Agency Theory (SAT) is frequently invoked (Beege et al., 2023; T. Liu, 2025; Wang et al., 2023) to suggest that human-like cues (gaze, gestures, etc.) foster a sense of partnership, activating social schemas that boost retention and transfer.

Virtual instructor research often draws on Embodiment Theory and Situated Learning Theory (SLT) (T. Liu, 2025; Wang et al., 2023; Y. Zhang & Pan, 2025), emphasising immersive VR interactions that simulate real-world contexts to promote deeper engagement and enhance knowledge retention.

5.2. Methodological considerations

Measurements of motivation, affect, and learner satisfaction repeatedly show up in the literature, mostly as self-report surveys, and are often where instructor presence shows clearer benefits, especially for affective instructors (Beege et al., 2023; Polat, 2023; Zhu et al., 2024). Similarly, cognitive load is also measured using subjective ratings. Beege et al. and Zhu et al. also include studies incorporating (visual) attention measurement mechanisms, such as those which compare dwell time on the instructor vs. the relevant visual material, often finding that attention can be increased overall by adding instructors, but not necessarily to the learning material. Studies measuring learning outcomes usually tracked retention and learning transfer.

5.3. Guidelines for Instructional Designers

Designers should navigate the conflict between social presence and cognitive load. While Stap et al. argue for maximizing social presence to foster interaction, Beege et al. (2023) argue that high social presence (via video) can be extraneous. The compromise appears to be instructional relevance: high-fidelity/high-presence avatars should be used for motivation, feedback, and social bonding, but potentially removed or minimized during deep cognitive processing tasks.

When using hyper-realistic avatar platforms in educational settings, preference should be made for systems which allow the learning designer to specify expressive emotions (leaning towards positivity in most cases), and use gestures and gaze based on the context to direct learner attention. If hyper-realistic avatars are used merely as "talking heads" without meaningful interaction, they may suffer the same distractive effect as that observed in some human videos - increasing extraneous cognitive load without aiding comprehension. Conversely, if these avatars can perfectly mimic the "positive instructor" behaviors identified by Zhu et al. - such as natural smiling and enthusiastic tone -they could theoretically replicate the emotional contagion effects previously exclusive to human actors.

Bearing in mind the sometimes conflicting reports in the literature, testing in small groups is important as results may not generalize across ages, educational levels and subjects being taught. When feasible, experiments should measure learning outcomes (including retention and transfer), attention (if eye-tracking software or a similar method is available), and self-reported motivation, satisfaction, and cognitive load.

6. Conclusion

This work covered the intersection of human and virtual instructor research, laying out the pedagogical theories and methodologies to be taken into consideration when designing learning experiences with human and/or human-like instructors. It sets the stage for future research incorporating hyper-realistic avatars into educational settings, which promises the social benefits of having human instructors while being programmatically controllable. This enables the scaling of educational content creation beyond what is imaginable at the moment. This paper aims to inspire future work in educational avatars that not only push the boundaries of realism, but also consider the importance of other controllable characteristics such as gestures, facial expressions, avatar appearance and tone of voice, while taking into account the ethical considerations of hyper-realistic human cloning, such as consent and misrepresentation of real humans.

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A COMPARATIVE ANALYSIS OF AI MODELS FOR SCENARIO-BASED LEARNING

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Abstract

Scenario-Based Learning (SBL) is a pedagogical approach that situates learners within realistic narratives to promote skill transfer, decision-making, and contextual understanding (Clark, 2012). With the rise of generative artificial intelligence, Large Language Models (LLMs) have become central to enhancing SBL by enabling adaptive dialogue, dynamic narrative generation, and personalized feedback (Liu, Yang, & Xu, 2023; Zhang, Wang, & Li, 2024). This paper presents a comparative analysis of LLM applications in SBL across immersive (VR/digital) and non-immersive (text-based and 2D) environments, focusing on education and safety training domains. The study incorporates a review of SBL literature and evaluation frameworks, highlighting how learning outcomes, engagement, and realism are assessed in current research (Lee, Park, & Kim, 2024; Kim & Torres, 2023). We also examine design processes underpinning SBL systems, including human-centered design, iterative prototyping, and collaborative scenario development with educators (WHO, 2022; Ahmed, Brooks, & Liu, 2023; Hu & Chan, 2025). Findings from recent studies (Liu et al., 2023; Rajputh, Seetharam, & Balasubramanian, 2019) indicate that LLM-driven systems support high levels of psychological fidelity and learner engagement, particularly in dialogue-rich contexts, though challenges such as prompt control and response reliability persist (Zhang et al., 2024). Finally, through this paper we aim to conclude that the most effective SBL implementations are built on hybrid AI architectures that combine the creativity and adaptability of LLMs with the precision and structure of rule-based or knowledge-driven components. Such hybrid designs enable educators to maintain control over content accuracy while benefiting from AI-driven flexibility. Additionally, robust evaluation frameworks that systematically assess learning outcomes, engagement, and realism are crucial to ensure both educational effectiveness and technical reliability. Together, these strategies provide a pathway toward developing realistic, adaptive, and safe learning environments powered by AI (Lee et al., 2024; Kim & Torres, 2023; Ahmed et al., 2023).

Keywords: *Scenario-Based Learning (SBL), Large Language Models (LLMs), virtual reality, educational technology, adaptive learning, human-centered design.*

1. Introduction

Scenario-Based Learning (SBL) has emerged as a powerful pedagogical approach that situates learners within authentic, context-rich narratives to promote skill transfer, decision-making, and deeper conceptual understanding (Clark, 2012). Traditionally, SBL environments relied on carefully designed branching scenarios or scripted interactions that provided realistic contexts for learners to practice complex tasks. With recent advances in generative artificial intelligence, particularly Large Language Models (LLMs), new opportunities have emerged to make SBL systems more adaptive, conversational, and personalized. Studies such as those by Liu, Yang, & Xu (2023) and Zhang, Wang, & Li (2024) demonstrate that LLMs can simulate dynamic dialogue, generate context-aware narratives, and respond intelligently to learner inputs in both virtual reality and text-based simulations, marking a notable shift from static scenario structures to interactive, learner-driven experiences.

Despite these advances, comparative evidence remains limited on how different LLMs influence key educational constructs such as psychological fidelity, learner engagement, and measurable performance outcomes across diverse SBL contexts. In parallel, prior research on SBL system design underscores the importance of incorporating human-centered and iterative development practices (Hu & Chan, 2025; Rajputh, Seetharam, & Balasubramanian, 2019). However, there is currently a lack of comprehensive synthesis on how these design methodologies are adapted, or need to be adapted, when integrating

generative AI components into scenario workflows. Moreover, while existing evaluation models emphasize engagement, knowledge retention, and technical fidelity (Ahmed, Brooks, & Liu, 2023; World Health Organization, 2022), few frameworks capture the nuanced dimensions introduced by LLM-based adaptivity, such as conversational coherence, ethical interaction patterns, and learner agency.

Addressing these gaps is essential for understanding how LLM-enhanced SBL systems perform, how they are designed, and how their impacts can be rigorously evaluated. To guide this investigation, our study is structured around the following research questions:

1.1. Research questions

1. How do current Large Language Models (LLMs) contribute to enhancing realism, adaptability, and learner engagement within Scenario-Based Learning (SBL) environments?
2. What design processes and pedagogical strategies have researchers employed to integrate LLMs effectively into SBL systems across educational and safety training domains?
3. Which frameworks and evaluation criteria are most effective for assessing the performance and learning impact of LLM-driven SBL systems?

The structure of our research is organized to explore how AI Models (LLMs) support Scenario-Based Learning (SBL). In Section 2, we review relevant literature on SBL pedagogy, early AI integrations, recent LLM applications, design approaches, and evaluation frameworks, identifying current gaps in comparative evidence. Section 3 outlines the methodology used for the comparative analysis, including study selection criteria, analytic dimensions, and synthesis procedures. In Section 4 we present our results and summarise how different AI models perform across immersive and non-immersive environments, assessing their effects on engagement, realism, adaptability, and learning outcomes. We then discuss these findings relative to the research questions in Section 5, highlighting design practices, evaluation trends, and implications for educational and safety training domains. Finally, we conclude in Section 6 by summarizing key insights and emphasizing directions for future work on hybrid architectures and comprehensive evaluation frameworks.

2. Background

2.1. Scenario-Based Learning (SBL) theoretical foundations

Scenario-Based Learning (SBL) is grounded in constructivist and experiential learning theories that emphasize authentic task engagement, situated decision-making, and reflective practice. Classic conceptualizations of SBL argue that learning is optimized when learners interact with realistic scenarios that require active problem solving and contextual application of skills, rather than passive reception of information (Clark, 2012). Contemporary educational technology research further situates SBL within broader theoretical frameworks such as adaptive learning and learner autonomy, demonstrating how narrative complexity, feedback loops, and cognitive engagement support higher-order learning outcomes (Liu et al., 2025). Together, these theoretical positions provide the basis for understanding how SBL environments can mediate cognitive, affective, and behavioral dimensions of learning, and why extensions, such as the integration of generative AI, must preserve alignment with pedagogical principles to maintain instructional integrity.

2.2. AI in SBL: From early tutoring to immersive LLM-Driven environments

AI in education has evolved from early intelligent tutoring systems (ITS) with rule-based adaptive feedback to modern LLM-enhanced environments. Traditional ITS frameworks (Tan, L. et al., 2025) supported learner engagement and procedural performance by diagnosing learner states and providing tailored hints, but interactivity and narrative flexibility were limited by static scripts.

Generative AI and LLMs now enable naturalistic dialogue, context-aware narratives, and real-time personalized feedback, extending beyond fixed responses (El Hajji, M. et al., 2025). In immersive VR, LLM-driven non-player characters scaffold exploration and enhance presence through adaptive dialogue (Gianni, A. et al., 2025). Design approaches emphasize human-centered, iterative development, integrating educator input, prompt engineering, and continuous feedback to align AI behaviors with pedagogical goals (Harder, N. et al., 2025).

Immersive and non-immersive SBL environments offer distinct advantages. VR supports embodied interaction, situational realism, and improved retention in professional and safety training (Hemminki-Reijonen, U. et al., 2025). Non-immersive 2D and text-based systems prioritize accessibility and scalability, leveraging LLMs to generate branching narratives and adaptive prompts (Stenseth, H. et al., 2025). Hybrid designs that combine narrative-driven LLM layers with optional immersive overlays can balance fidelity, engagement, and broad accessibility.

2.3. Evaluation frameworks in SBL

Evaluating SBL effectiveness necessitates frameworks that capture multiple learning dimensions including knowledge acquisition, engagement, fidelity, and transfer. Historically, evaluation in SBL research (Lee, A. et al., 2023) has incorporated performance tasks, retention tests, and subjective measures of presence and satisfaction, particularly in immersive environments where psychological fidelity correlates with motivation and engagement. Safety training research (Hemminki-Reijonen, U. et al., 2025), for example, has applied mixed-methods evaluation designs that combine task performance (e.g., correct procedural steps) with subjective self-efficacy and system acceptance measures to ascertain both skill outcomes and learner experience in complex, high-risk scenarios.

However, the integration of generative LLMs introduces new evaluation needs that extend beyond traditional metrics. This is because of the adaptive, dialogic nature of LLM output that requires assessment of conversational coherence, alignment with learning objectives, ethical compliance, and interaction quality, which are not fully addressed by conventional frameworks (Voultsiou, E. et al., 2025). Emerging meta frameworks (Mustafa, M. et al., 2024), such as multidimensional pyramids incorporating safety, trustworthiness, and operational effectiveness, offer promising starting points for capturing AI-specific constructs like reliability and human-AI interaction quality alongside classic pedagogical outcomes. These frameworks advocate a layered approach where core instructional safety and ethical compliance anchor higher-order assessments such as usability, personalization quality, and learning impact. For comprehensive evaluation in LLM-augmented SBL, melding these AI-centric constructs with established educational outcomes enables a more nuanced interpretation of both what learners accomplish and how they engage with generative adaptive systems.

3. Methodology

The core of this research involves a systematic review of literature on AI applications in Scenario-Based Learning (SBL), conducted following PRISMA 2020 guidelines (Haddaway et al., 2022). Database searches were performed in IEEE Xplore, SpringerLink, and ScienceDirect using Boolean queries targeting SBL and LLM applications published between 2022 and 2025 (see Appendix 1). Records were deduplicated, screened by title and abstract, and assessed for full-text eligibility based on predefined inclusion criteria. The PRISMA flow diagram (Appendix 2) documents the screening and selection process to ensure transparency and reproducibility. Searches yielded 97 open-access review articles from SpringerLink, 1 from IEEE Xplore, and 4 from ScienceDirect, totalling 102 articles. Following title and abstract screening, 50 articles were retained, and full-text assessment resulted in 10 studies selected for detailed synthesis. These studies were tabulated in Figure 1 and are described in Section 4.

4. Results

The ten literature articles were categorised by the title of the review, author, their immersiveness, which directly maps to immersive or non-immersive scenarios, and their use case, which explains the field that the literature was directly impacting.

Figure 1. Tabulated results of the literature overview used for synthesis.

Title	Authors	Immersive / Non-Immersive	Use Case
AI-Supported VR Ethical Dilemmas	Liu et al., 2025	Immersive	Education - Ethics
VR Simulation in Teacher Training (FCT)	Hu & Chan, 2025	Immersive	Education
AR Sustainability Scenarios	Ahmed et al., 2023	Immersive	Education
"Bill": AI Clinical Scenario Coach	Rajputh, Seetharam, & Balasubramanian, 2019	Immersive	Medicine
AI-GBL Leadership Simulations	Lee et al., 2024	Immersive	Education
GenAI Patient Simulator versus VR	Lee, Park, & Kim, 2024	Immersive	Medicine
ChatGPT for Pre-Service Teacher Scenarios	Liu, Yang, & Xu, 2023	Non-Immersive	Education
AI-Generated Scenario Lessons	Zhang, Wang, & Li, 2024	Non-Immersive	Education
Online Nursing Scenario Modules	Kim & Torres, 2023	Non-Immersive	Medicine
Generative AI Literacy in SBL	Rajputh et al., 2025	Non-Immersive	Education

5. Discussion

5.1. Realism, adaptability, and learner engagement

Large Language Models enhance Scenario-Based Learning by increasing cognitive realism, adaptability, and engagement across immersive and non-immersive environments. In VR and AR scenarios, LLM-driven agents dynamically respond to learner actions, supporting realistic decision-making and professional skill rehearsal (Lee et al., 2024; Ahmed et al., 2023). In non-immersive text-based or 2D environments, LLMs provide personalized feedback and coherent narrative branching, improving perceived authenticity and motivation despite limited sensory immersion (Liu, Yang, & Xu, 2023). Across modalities, LLMs strengthen social and cognitive fidelity, enabling meaningful learning transfer.

5.2. Design processes and pedagogical strategies for AI and LLM integration

Effective LLM integration relies on human-centered, iterative design. Structured scenario authoring, prompt scaffolding, and educator oversight ensure pedagogical alignment and reliability (Rajputh et al., 2019; Hu & Chan, 2025). Pedagogically, LLMs are most effective when embedded in guided experiential learning: as intelligent agents in immersive environments or adaptive tutors in non-immersive contexts (Ahmed et al., 2023; Kim & Torres, 2023). Hybrid AI architectures combining generative flexibility with rule-based controls are consistently preferred.

5.3. Evaluation frameworks for LLM-Driven SBL systems

Evaluation frameworks in recent SBL research commonly assess learning outcomes, engagement, and performance, with immersive studies additionally emphasizing presence and psychological fidelity (Lee et al., 2024; Kim & Torres, 2023). However, the introduction of LLM-based adaptivity necessitates expanded criteria, including conversational coherence, feedback quality, learner agency, and ethical AI behavior (Ahmed et al., 2023; Hu & Chan, 2025). The literature supports the use of mixed-methods evaluation approaches and highlights the need to extend existing frameworks to systematically assess both educational impact and AI reliability in LLM-driven SBL systems.

6. Conclusion

In our study, we sought out to review how AI models and Large Language Models enhance Scenario-Based Learning by supporting adaptive interaction, cognitive realism, and learner engagement across both immersive and non-immersive environments. However, their educational effectiveness depends on deliberate integration rather than unrestricted generation. The reviewed literature indicates that hybrid AI architectures, combining the generative adaptability of LLMs with rule-based or knowledge-driven controls, provide the most effective balance between flexibility, instructional accuracy, and safety. These findings directly inform the evaluation criteria adopted in our work, which extend beyond traditional learning outcomes to include learner engagement, realism, conversational coherence, adaptive feedback quality, and learner agency. Future research should empirically validate these criteria through controlled comparative studies of different AI architectures, including large general-purpose and domain-specific models, while also examining long-term learning transfer and ethical considerations in safety-critical training contexts to ensure that AI-enhanced SBL systems remain both effective and trustworthy.

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EXPLORING THE IMPLEMENTATION OF SUPPORT SERVICES IN ENHANCING TEACHERS' INCLUSIVE PEDAGOGICAL PRACTICES

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Abstract

Effective implementation of support services depends on the enhancement of inclusive teacher pedagogies. However, principles of the medical model predominate traditional teacher pedagogies hence a need for teacher training that promotes inclusive practices. This study aimed at exploring teachers' pedagogical practices for effective support provision within mainstream schools. Using a qualitative approach in an interpretivist paradigm we employed a case study design to collect data through lesson observations and semi-structured interviews, from 8 teachers and 6 school leaders (Head of department, deputy principal and school principal) in two South African mainstream schools who were purposively sampled [7 participants from each school]. Data was analysed using thematic data analysis because it provides a flexible yet rigorous approach for identifying, analysing, and interpreting patterns of meaning within qualitative data. The findings revealed that the 1) inequitable classroom engagement inhibits inclusive pedagogical practices; 2) multigrade classroom intensifies the complexity of inclusive teaching and 3) the effect of insufficient in-service training and monopolised leadership roles on support provision. Significance of this study is on how systemic collaboration or lack thereof affects improved pedagogical practices and inclusive learning outcomes.

Keywords: *Inclusive practices, pedagogical practices, support services.*

1. Introduction and background

The effective implementation of learner support services in mainstream schools is closely linked to the enhancement of inclusive teacher pedagogies (Brennan, King & Travers, 2021). Inclusive pedagogical practices require teachers to adopt approaches that accommodate diverse learning needs; however, traditional pedagogies in many contexts remain shaped by the medical model of disability, which locates learning difficulties within the learner rather than within systemic, pedagogical, and environmental barriers (Florian & Black-Hawkins, 2011; Engelbrecht & Green, 2018). This misalignment underscores the need for targeted in-service teacher training and professional development programmes that promote inclusive, learner-centred practices consistent with the social and inclusive models of support (Ainscow, 2020).

Moreover, inclusive pedagogies require teachers to shift from deficit-oriented perspectives to approaches that recognise learners' strengths, interests, and contextual realities (Pirzada, 2025). This is because when teachers rely heavily on the medical model, they may unintentionally perpetuate exclusion by focusing on diagnosis, labelling, and categorisation rather than on adapting teaching strategies to reduce learning barriers (Slee, 2019).

In contrast, insufficient teacher training on inclusive pedagogies that include differentiated instruction, universal design for learning (UDL), and collaborative problem-solving, disable teachers from creating flexible learning environments that respond to diverse learner profiles (CAST, 2018). Implementation of support services depends on teacher efficacy on these mentioned strategies which will capacitate them to allow all learners to participate meaningfully and access the curriculum on equitable terms. Furthermore, ongoing professional development is essential for equipping teachers with the competencies and confidence required to implement inclusive education effectively. Evidence shows that professional development initiatives that incorporate mentoring, reflective practice, and classroom-based coaching significantly improve teachers' attitudes and skills for working with diverse learners (Forlin, 2012; Sharma & Loreman, 2016). Such training, when grounded in the social model of disability, enables teachers to interrogate their assumptions and adopt pedagogical strategies that address systemic and environmental barriers rather than individual deficits (Florian, 2015). Social model of disability draws on

redirecting attention to how systemic and environmental factors impair different-abled learners. This study therefore aims to explore teachers' pedagogical practices to strengthen the provision of support services within mainstream schools as a way to contribute to the broader goal of developing inclusive and responsive learning environments.

In addition, the successful operationalisation of inclusive support services depends on teachers' willingness and ability to collaborate with support specialists, parents, and other stakeholders. Research demonstrates that collaborative inquiry and team-based problem-solving strengthen teachers' understanding of learner diversity and enhance their capacity to provide responsive pedagogical support (Hornby & Graham, 2013). Collaboration also broadens professional knowledge and encourages teachers to shift away from traditional instructional routines toward more reflective, inclusive, and contextually grounded practices (Walton, 2018). Conversely, different stakeholders in support services continue to work as separate entities, which continues to hinder successful implementation of inclusive practices (Jama & Lunga, 2024). As a result, developing strong professional learning communities within schools becomes critical for sustaining inclusive teaching approaches.

2. Design

This study aimed at exploring teachers' pedagogical practices for effective support provision within mainstream schools in one South African province. Our focus on the paper is on teachers' pedagogical practices for effective support provision within mainstream schools. Qualitative approach embedded in an interpretivist paradigm was employed to carry out this study as we wanted to understand how teachers make sense of their pedagogical practices while enhancing support services in their classrooms (Rose, 2020). A case study design in which two schools in the North West province was purposively sampled as research sites. A total of 14 participants were purposively sampled comprising 8 teachers and 6 school leaders (3 from each school) which include heads of departments, deputy principals and principals.

3. Objectives

The main objective that guided this study was to explore teachers' pedagogical practices for effective support provision within mainstream schools in one South African province.

4. Methods

Data was collected through observations that were followed by semi-structured interviews to complement field notes taken during the observations as we wanted to better understand teachers' detailed understanding of support services and pedagogical practices related to inclusive practices (Creswell & Creswell, 2018). In our first visit to schools, before they signed informed consent, we explained that we will also have lesson observations. This data generation method helps to capture what participants do in relation to the research question than on what they say. As researchers we were involved from the beginning of the lesson, to observe inclusive related pedagogical practices during a lesson when the teacher is teaching and having to support those learners whose learning needs additional support. To mitigate the influence of Hawthorne effect on participants' behaviours, we triangulated through semi-structured interviews with follow up questions based on the observations during the lesson. Semi-structured interviews allow participants to provide nuanced qualitative data in which perspectives are shared in a conversational manner but guided by research questions (Quintela, Vinuesa, Dembélé, & Ayotte-Beaudet, 2024). Data collected through semi-structured interviews tends to provide in-depth exploration that leads to rich and detailed data. Thematic analysis was used following Braun and Clarke's phases to describe teachers' pedagogical practices as was observed in their classes in relation to their individual perspectives as was captured through semi-structured interviews (Braun & Clarke, 2022).

5. Data presentation and discussion

We present data that emerged from the two data generation methods that we used in this study and as a way to differentiate data from the two methods, P and a number was used to identify data that emerged from semi structured interviews while LO stands for data that emerged from lesson observations.

Inequitable Classroom Engagement that inhibits inclusive pedagogical practices

The narratives suggest that failure to give opportunities to all learners tends to obscure learning needs of those learners who might be experiencing barriers to learning as identification of misinformation, or misunderstanding can only be found when a learner is given an opportunity to show whether learning took place or not

> *The teacher only provided those who raised their hands with opportunities to respond to questions, while ignoring those who did not volunteer to respond.* [LO 1]

Learner engagement is one important aspect of learning, in a case where it is not encouraged equitable for different learners it becomes an additional barrier. According to Dontagon et al. (2024), a lack of equitable classroom engagement poses significant challenges for both teachers and learners, largely due to inadequate preparation, training, and professional support. These limitations hinder teachers' ability to implement inclusive pedagogical practices effectively, particularly in complex teaching contexts such as multigrade classrooms. Moreover, a one-size-fits-all approach is insufficient for addressing the unique demands faced by multigrade teachers, who require context-responsive strategies tailored to their diverse learner groups (Dontagon et al., 2024).

Multigrade classroom intensifies the complexity of inclusive teaching

Multigrade classes require much time and passion from the teacher who is expected to service learners of different grades in one classroom while also having to cover more than one subject in many instances.

> *The observations were in a multigrade class in which 3 foundation phase are taught at the same time, even though the teacher tries to cater for all the grades, but the teacher may not have enough time to identify learners experiencing barriers to learning, and in some cases may not be in a position to provide additional support as the time is already divided between four subjects for the 3 grades, and having to cover annual teaching plan for each grade as these are monitored.* [LO 2]

A multigrade classroom intensifies the complexity of inclusive teaching and if the teacher is not supported with appropriate training, resources, and collaboration with support services, it can lead to them overlooking barriers to learning; being inconsistent support and employ teaching practices that unintentionally exclude certain learners. According to Dontogan, et al. (2024), multigrade classrooms present numerous challenges related to classroom practices. One of the key difficulties is time management, which often leads teachers to employ what is referred to as the "jump-jump strategy," whereby instruction is directed at one grade level while learners from another grade work independently. Teachers also rely on peer teaching as a complementary practice to manage diverse learning needs. Despite their best efforts, multigrade teachers continue to face substantial challenges in delivering effective instruction (Dontogan et al., 2024).

Effect of insufficient in-service training and monopolised leadership roles on support provision

School policies are not always communicated transparently to all teachers which affect how they engage with their day-to-day duties including identification of learners experiencing barriers to learning. Principals tend to draft policies independently without involving other teachers even those who are in the school management team.

> *As head of department (HOD), I am not sure of inclusive related policies in our school, it can be that it is not communicated to us. We do have school-based support team (SBST), that does identification and complete support needs assessment (SNA) forms and make copies of their work, and thereafter, call their parents. We normally let parents be the ones that approach the special schools as if it is done by the school it takes time for them to be placed.*

According to Khoshhai and Guraya (2016), effective leaders are able to identify needs and develop action plans to achieve desired outcomes that improve a given situation or context. Similarly, Sydänmaanlakka (2003) argues that leadership should not be monopolised; rather, it should be broadened to include various spheres of influence, ranging from individuals and teams to organisations and societies. In environments where leadership is centralised and constrained by restrictive policies, genuine leadership cannot flourish.

6. Conclusions

The findings accentuate that improved pedagogical practices and inclusive learning outcomes are strongly influenced by the quality of systemic collaboration among stakeholders such as teachers, school leadership and other support structures. Where collaboration is fragmented, teachers experience inconsistent support and unclear guidance, which undermines their ability to implement inclusive teaching effectively. Conversely, strong systemic collaboration provides coherent support, shared accountability, and aligned interventions, enabling teachers to respond to diverse learner needs more confidently and competently. Inclusive practices compel the education system to improve its functionality by eliminating multigrade teaching. Multigrade teaching affects the effectiveness of identification of learning barriers and support thereof owing to the demands of diverse classrooms and insufficient teacher training.

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LANGUAGE EDUCATION: CULTURAL MEDIATION THROUGH CREATING AN IMAGE OF THE FOREIGN COUNTRY

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Abstract

An important part of language education is the development of students' intercultural competence, as attested also by relevant international methodical documents, such as the Common European Framework of Reference for Languages. Such a competence includes the use of the sociolinguistic dimension of communication and suggests the presentation of imagological discursive types of text in the language acquisition process. As a result of the recent national Slovak school curriculum reform in the area of language education, possibly two foreign languages have been established in state schools as early as at the first stage of primary education. At the same time, according to respective national methodical documents, foreign language teaching should emphasize the context of intercultural mediation from the lowest language levels onwards. Therefore, we decided to examine selected Italian language textbooks for foreigners, published by Italian editors and widely used in the Slovak primary and high schools at language levels A1-B1, with the aim to identify the methods and discourse used to create an image of Italy, its culture, and its identity. Using the literary methods, we determined the types of texts presented and described the use of cultural stereotypes and cultural confrontations in relation to stereotyped national identity to create an image of a given country. We proceed from the assumption that the basic and valid strategy of imagological creation is to integrate into the language some precise conceptual ideas that are characterized by key words. Therefore, we pay particular attention to the vocabulary and themes of the selected types of text. The result of our research is a set of key themes and words that are used in Italian language textbooks for foreigners as a basis for creating an image of Italian culture.

Keywords: *Cultural discourse, imagology, linguistic vehicle, foreign language.*

1. Introduction. Objectives and methodological assumptions

In recent years, numerous studies have highlighted how textbooks continue to convey gender, ethnic and cultural stereotypes, as well as political and moral views that influence the formation of students' identities, confirming the hypothesis that nations tend to reinforce their own view of foreign cultures through such representations. This is a phenomenon of scientific circularity, as highlighted by Dumez (2025). In language teaching, Blanchet and Chardenet (2011) emphasise that language teaching is always situated, permeated by identity, political and social issues.

In the context of Slovak school system, the second language, included Italian, is proposed to be enhanced in the nowadays conditions. According to CEFR (companion volume, p. 30) an effective practical comunication in the second language is anchored in the pluricultural competence, stressing its semantic aspects: "Both the CEFR descriptive scheme and the action-oriented approach put the co-construction of meaning (through interaction) at the centre of the learning and teaching process". The co-construction of meaning leads directly to the use of such interpretations of the given text to satisfy both learner's refined knowledge and expectations or cultural projections on the other culture. By comparing various socio-cultural elements, the learning process leads to discover to what is general and what is specific in the given cultural feature, but also what is so important that provides an identity element of the comunicating culture. In the process of meaning de-coding and re-coding, most of all the receptive skills and reading skills, as well as general culture background of the reader / pupil / student are of stressed importance. These can be facilitated by teacher's intervention oriented on the diversification of the entire educational process (Stranovská & Haringa & Ficzere, 2025). Thus, a choice of images presented to the pupil, either in the textual or in any other form, is a strong vehicle to comunicate a country's or national identity as wished to be seen and perceived by the learner. Beyond their explicit pedagogical objectives, such representations

also contribute to what can be defined as educational implicit, namely the set of norms, values and identity models conveyed indirectly through teaching materials. This implicit dimension, often perceived as neutral or self-evident, plays a central role in shaping learners' perceptions of the foreign culture without being explicitly formulated as curricular content.

In this aspect, in our opinion, the importance of text is stressed. Indeed, among "mediation activities" indexed in the CEFR there are listed also "expressing a personal response to creative texts (including literature)"which means, in other words, an interpretation and contextualization of the given portion of literary text. Also in the case of "analysis and criticism of creative texts (including literature)" we are talking about the textual competence in active and passive form, as well as about the learner's sensibility in reading and interpreting a verbal or textual message. In this ambience, abundance of translations of world-famous contemporary Italian authors and texts to Slovak, may create a good background for creating an image of Italy as a cultural and literary reference point. In accordance to Maria Corti (1976), "Literature, by its very nature, reflects a socio-cultural context, and therefore every particular literary text can be understood as an expression or response to the cultural environment and historical context of its origin and subsequent functioning, also understood in terms of the literatures and cultures that receive it in the form of translation". Nowadays, texts in schoolbooks are supported and reinforced by multimedial texts and contents (such as videos, interactive texts and exercises, update services in the National politics and culture and many other resources) offered by various platforms pertinent to the single publisher houses or textbook lines.

A recent document released by the Slovak Ministry of education, research and sports, which introduces a curricular school reform, defines the contents and performance standards in accordance to the selection of the input text. We can read in Educational standards in Language and Communication, subfield Foreign Languages (Vzdelávacie štandardy. Vzdelávacia oblasť Jazyk a komunikácia. Podoblasť Cudzie jazyky, p. 11): "Various types of texts in paper, audiovisual and digital form are used in the development of communicative language skills. The choice of texts must be appropriate to the level of communication, age and interests of the pupils: extracts from fairy tales and illustrated stories, short descriptions, songs, poems, nursery rhymes, cartoons, posters, notices, leaflets, etc.". In addition, the input text should be in accordance to topics and thematics proposed in CEFR (such as "family, "housing", "human body", "fashion", "travelling", "education", "leisure time", "gastronomy", "comparing cultures", "shopping" and many others, just to list those who coincide with the image of Italy as a reference point in gastronomy, tourism, fashion, art and culture).

Remarks Dörnyei (2007, p. 27): "Thus, quantitative researchers follow a 'meaning in the general' strategy, whereas qualitative researchers concentrate on an in-depth understanding of the 'meaning in the particular". Therefore we offer an analysis of the single contents in the selected manuals as representative examples of the tendencies and strategies of comunication of cultural contents and creating an image of the foreign country, respecting the affermation of Cohen et al. (2007, p. 476): "Content analysis, then, describes the manifest characteristics of communication [...] infers the antecedents of the communication (the reasons for, and purposes behind, the communication, and the context of communication) [...] and infers the consequences of the communication (its effects)."

2. Discussion

Our aim was to examine selected Italian language textbooks for foreigners, published by Italian editors and widely used in Slovak primary and high schools at language levels A1, for teaching a second foreign language at adolescent age, with the aim to identify the methods and discourse used to create an image of Italy, its culture, and its identity centered for such a learner's profile. We have described some cultural stereotypes and cultural confrontations in relation to stereotyped national identity to create an image of Italy, centering mostly on verbal texts, eventually accompanied by pictures. We have proceeded from the assumption that the basic and valid strategy of imagological creation is to integrate into the language some precise conceptual ideas that are characterized by key words. Therefore, we have paid particular attention to the vocabulary and themes of the selected types of text. The result of our research is a set of distinctive key themes and words that are used in Italian language textbooks for foreigners as a basis for creating an image of Italian culture. These circularly repeating and gradually widened key themes and cultural images are also implicated by the textbook methodical structural sections dedicated to lexical and intercultural competences aimed to be achieved. We did not pay as much attention to general cultural features common to mostly all national cultures (such as numbers, colors, time measurement and many others).

Table 1. Key themes and words used to create an image of Italy in the examined manuals.

Topic	***Image***	***Keywords***	***Message***	***Notes***
Learning Italian	Pictures of Italy		Italian language as a culture vehicle	
	Italian gestures		the importance of paralinguistic competence	in the communication often the most important part of the message is not expressed by words
	Social hierarchy and contacts	*ciao, buongiorno, arrivederci, arrivederLa*	greetings and their formal context	
	Famous Italian cities and places	*quartiere, città d'arte*	Italy as a reference point of European and world-wide tourism	rich visual material (for ex. video-tasting section *In viaggio con Sara* in «Nuovo Espresso Plus»
Gastronomy	Italian coffe	*caffè*	drinks and food as cultural and social vehicles	social rituals connected with various types of coffee
	Italian meal World-wide famous Italian receipes	*pranzo, colazione, cena, bar, ristorante, osteria*	social meaning of a common dinner	Food as a social mediator; Confronting national customs in restaurants
	Typical Italian products	*prodotti tipici, D.O.C., D.O.P., sapori*		
Festivities, occasions	Calendario delle feste nazionali	*regalo, la Notte Bianca, Festa della donna, San Valentino, sagra, festa, piazza, auguri, compleanno, brindisi*	Italians as joyful, warm-hearted, and willing; typical gifts for selected occasions (often related to love)	gifts as social interaction symbols; Italians are shown in various pleasant social interactions
Family	Traditional and contemporary Italian family	*famiglia, amici, sposi, matrimonio, vicini, amore*	Italians as sociable and family-loving	interesting: in stamped manuals images of traditional family happiness, but in complementary on line materials also other social tendencies
Travelling	Moving in the city and outside	*strada, vicolo, via, viale, albergo, cartelli stradali, mezzi di trasporto*	human voyages; organization and discipline in city life	
Leisure time, Sports	Mountains Seaside Sport campus	*vacanza, sport, correre, nuotare, andare in montagna, andare al mare*	pictures of businessmen in typical Italian blue shirt and pictures of young people doing sports or being at home	sports and free time as social occasions; organised and active free time as promotional campaign to buy free-time products
Housing	Typical Italian urban and countryside architecture	*casa, appartamento, villa*	housing as an economical and social issue related to the topic of "family"	

To stress a comparative aspect of intercultural communication, the manuals contain specific sections in which the images of Italy are proposed and systemized (for ex. *Culture a confronto* in «Chiaro»; *Caffè culturale* in «Nuovo espresso plus»). In first it works mostly with pictures, then words and concepts. The pertinent video portions present always young people, friends or couples, with typical Italian acting, gesturing and clothing, in representative Italian ambience (the short stories are located mostly in idyllic ambiences of Florence or Rome).

At higher language levels, the cultural concepts in the examined manuals are presented widely by portions of literary text which are either canonical in the traditional sense of this word or which are proposed to reform it into a new literary, thus cultural canon. In the postmodern era, the literary canon has been repositioned as a factor that identifies a certain community: "The literary canon contains the identity values that shape the community and every individual who belongs to it" (Domenichelli, ed.). From an educational point of view, the literary canon can also be defined as "the dominant object of knowledge in literary education" (Magalová, 2013). In the textbooks chosen, we can see that, alongside classical and canonical

authors, cultural mediation is carried out mainly by representatives of commercially successful forms and genres (such as detective novels, novellas, biographies, etc.), bearers of a moral heritage or values closely linked to key moments in the development of Italian society. Thus, analysing the textbooks of the «Via del Corso» series by Edilingua and «Magari» by Alma Edizioni, at levels A1 - B2 respectively, we come across, for example, the works of Leonardo Sciascia on the theme of the *mafia*, linguistically interesting treatments by Andrea Camilleri, or the cinematic treatment of canonical texts of early Italian literature. Canonical writers (e.g. Manzoni, Eco, Dante, Ariosto) are often presented without textual excerpts in a cultural section dedicated to general knowledge (Marin & Diadori, 2019). We may also come across passages by Alessandro Baricco, interviews or brief notes on Antonio Tabucchi, Massimo Carlotto or Giorgio Faletti (De Giuli & Guastalla & Naddeo, 2013). As for thematics, (young) love and interpersonal relationships in general, e.g. authors as Federico Moccia are mediated. At the highest levels of linguistic competence (C1-C2), publishers offer lesser-known and perhaps more engaging authors, because they are very contemporary, such as Mauro Corona, Erri De Luca, Stefano Benni or Valeria Parrella, while also re-proposing canonical authors such as Antonio Tabucchi, Leonardo Sciascia or Italo Calvino (De Giuli & Guastalla & Naddeo, 2013).

3. Conclusions

In a contemporary context marked by controversy over the identity content of teaching materials, this article offers an interpretation that could be useful for understanding the dynamics of identity communication through education. Far from being neutral tools, school textbooks are devices for transmitting values, representations and social norms, often implicit, that reflect dominant worldviews of the emittent. The observations made here above raise ethical questions regarding the responsibility of textbook designers and publishers, whose lexical, visual and thematic choices contribute not only to linguistic learning but also to the construction of cultural hierarchies and normative representations of the foreign country. Nevertheless, the strategy of imagological creation regards both the sender's intention and the recipient's refined imagination, his sensibility and interpretation skills. It is therefore specific for every relationship between two (or more) cultures that are communicating. In our case, we have focused strictly to Italian imagological proposal as reflected by elementary language level textbooks distributed in Slovakia. Whether through language education and intercultural mediation or through travel and other forms of imagological discourse, the image of the Other plays a crucial role in the creation of personal and national identities (Píšová, 2025).

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ESCAPING THE PATHOGEN: AN EDUCATIONAL ESCAPE ROOM AS AN ASSESSMENT TOOL FOR MICROBIAL PATHOGENESIS SUBJECT IN HIGHER EDUCATION

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Abstract

This study presents the design, implementation, and evaluation of an Educational Escape Room (EER) employed as a summative assessment tool within the Microbial Pathogenesis elective course for the Bachelor's Degree in Biochemistry and Biomedical Sciences. The primary objective was to develop a gamified resource aligned with the principles of the European Higher Education Area (EHEA), facilitating the integration of theoretical and practical contents regarding the emerging pathogen Vibrio vulnificus. The activity was implemented in a 'hall escape' format with a sequential puzzle structure, incorporating tasks based on real laboratory practices such as pathogen isolation, multiplex PCR identification, antibiograms, and virulence factor characterization. Results from the pilot and final implementation demonstrate high student engagement, significant activation of creative thinking, and a positive perception of the activity as an effective, sustainable, and replicable assessment strategy that fosters transversal competencies including teamwork and critical thinking under pressure.

Keywords: *Educational escape room, gamification, higher education, microbial pathogenesis, summative assessment.*

1. Introduction

In recent years, the landscape of Higher Education has undergone a significant transformation, moving away from traditional content-centred models towards student-centred approaches that prioritise 'learning to learn' (López, 2020). Within the framework of the European Higher Education Area (EHEA), there is a growing emphasis on active methodologies that promote student autonomy, critical reflection, and collaboration. Among these methodologies, gamification—the use of game design elements in non-game contexts—has emerged as a powerful strategy to enhance academic performance and motivation (González-de la Torre et al., 2024).

Specifically, the Educational Escape Room (EER) has gained traction as an innovative teaching and assessment tool. Unlike recreational escape rooms, EERs integrate curricular content into their puzzles, requiring students to master specific knowledge and skills to advance and 'escape' within a limited time (López-Belmonte et al., 2020). While the literature documents successful experiences in health sciences, including nursing and pharmacy, there remains a need to standardise criteria for their implementation as summative assessment tools in biomedical sciences.

2. Design

The activity focuses on *Vibrio vulnificus*, an aquatic pathogen of relevance to public health because, due to climate change, it is spreading to regions where it was not traditionally found, causing serious diseases such as sepsis (Carmona-Salido et al., 2026). The EER was structured as an escape room, allowing multiple groups to play simultaneously in a single room without the need for complex physical alterations to the university infrastructure.

2.1. Narrative and structure

The narrative immersed students in a simulated public health crisis. Participants received a mysterious email from a fictional researcher, 'Dr M.L.', requesting urgent assistance to identify a pathogen

causing an infection acquired in the Albufera Natural Park. Upon arrival, an introductory video set the scene, initiating a 40-minute countdown. The game followed a sequential or linear path, where the solution to one puzzle provided the code or key to unlock the next. This structure was chosen to facilitate the monitoring of student progress and to ensure that the entire team focused on a single complex task at a time, thereby fostering debate and consensus.

2.2. Puzzle configuration

The EER comprised six main puzzles (Figure 1), each corresponding to a specific practical unit of the course syllabus regarding *V. vulnificus*. The puzzles were designed to be scientifically rigorous while maintaining ludic characteristics:

- Puzzle 1 (Isolation): Students identified colony morphology on selective media (TCBS, VVM) to distinguish *V. vulnificus* (yellow on VVM, green/translucent on TCBS).
- Puzzle 2 (PCR Identification): Participants analysed a simulated electrophoresis gel using a transparency overlay to determine the presence of virulence genes (*vvhA*, *pilF*, *fpcrp*).
- Puzzle 3 (Antibiogram): Students interpreted E-test strips to determine Minimum Inhibitory Concentration (MIC) and resistance profiles.
- Puzzle 4 (Enzymatic Activities): Analysis of protease activity and haemolysis in wild-type versus mutant strains.
- Puzzle 5 (Theoretical Concepts): A matching game reinforcing terms like immune evasion and bacteriophages.
- Puzzle 6 (Horizontal Gene Transfer): Analysis of bacterial conjugation diagrams to identify donor, recipient, and helper cells.

2.3. Materials

To bring this educational escape room to life, simple, accessible, and sustainable materials were chosen, proving that educational innovation does not necessarily require a large financial investment. The design of the challenges was a purely artisanal process, where every element was handmade to create an immersive and safe experience for the students.

The project's "toolbox" combined everyday items with specific adaptations for the laboratory environment:

- Stationery and organisation: Envelopes, printed notes, worksheets, and posters with specifically designed iconography (such as the fish and human symbols) were used to guide the narrative and the puzzles.
- Security and progression systems: Cardboard boxes, trays, and physical padlocks were used to structure the game. Access to the challenges was managed via strips of paper taped to the flaps of the boxes, which could only be released by deciphering the corresponding codes.
- Adapted laboratory equipment: To ensure safety in a conventional classroom, glassware was replaced with plastic tubes. A key detail in their manual preparation was covering the clues with Sellotape to protect them from contact with liquids and ensure they remained intact throughout the activity.
- Game pieces and logic: Individual letter tiles were handcrafted for students to manipulate and form scientific terms. Likewise, visual and logical diagrams were designed and printed for the conceptual puzzles.

This manual assembly was complemented by the use of accessible technology and an introductory video—edited specifically for the project—which transported the students into the "clinical case" scenario they were tasked to solve.

3. Objectives

The primary objective of this study was to develop a gamified resource aligned with the principles of the European Higher Education Area (EHEA), facilitating the integration of theoretical and practical contents regarding the emerging pathogen *V. vulnificus*. Specific objectives included:

1. To demonstrate that an EER can serve as a rigorous, low-cost, and scalable summative assessment tool.
2. To evaluate technical knowledge alongside soft skills such as teamwork and critical thinking under pressure.
3. To foster student well-being by reducing the anxiety typically associated with traditional exams.

4. Methods

4.1. Context and participants

The study was conducted with fourth-year students of the Degree in Biochemistry and Biomedical Sciences from de University of Valencia (Spain). The cohort consisted of 32 enrolled students, organised into four groups of eight participants to ensure equitable participation and collaborative problem-solving. The EER was designed as a summative assessment of the laboratory practicals for the Microbial Pathogenesis elective.

4.2. Implementation and validation

A pilot trial was conducted with two students prior to the main event to identify potential design flaws and refine the clarity of the clues. Based on this pilot, adjustments were made to the visibility of initial clues and the visual cues on simulated E-test strips. Evaluation of the final implementation was conducted using the Gameful Experience Scale (GAMEX) to measure dimensions such as enjoyment, absorption, and creative thinking (Parra-González & Segura-Robles, 2019). Additionally, a survey was used to assess student perception of the activity as an assessment tool.

5. Discussion

The results of this study align with previous research suggesting that EERs promote active learning and student motivation. By transforming the assessment into a narrative-driven challenge, the activity succeeded in shifting the students' focus from passive memorisation to the active application of knowledge.

5.1. Student engagement and perception

The GAMEX scale results revealed a highly positive reception. "Enjoyment" scored a mean of 4.9/5, and "Absorption" reached 4.47/5, indicating high immersion, as it was also showed in other studies (Grupel et al., 2022; Arrue et al., 2025). Crucially, the 'Negative Effect' dimension was very low (1.35/5), confirming that despite the pressure, students did not feel frustrated. Regarding the "Dominance" dimension (3.29/5), the moderate score suggests that groups functioned through consensus rather than individual dominance, a desired outcome for developing transversal skills. Survey data indicated that 100% of participants would repeat the experience. Students rated the EER highly for fostering teamwork (4.92/5) and agreed it was a valid tool for assessing knowledge (4.8/5).

5.2. Pedagogical implications

A key finding is the successful use of the EER for summative assessment. While often used for formative purposes, this study demonstrates that with rigorous design, EERs can effectively evaluate complex technical competencies (López-Pernas et al., 2019). The sequential structure ensured that students engaged with every content block, preventing them from bypassing critical learning outcomes. Furthermore, the 'hall escape' format proved logistically viable and sustainable for university classrooms.

6. Conclusions

The implementation of an Educational Escape Room in the Microbial Pathogenesis course has proven to be an effective, motivating, and rigorous strategy for summative assessment. The activity successfully integrated theoretical and practical concepts related to Vibrio vulnificus within a stimulating environment. The study concludes that:

- High Acceptance: The format is highly valued by students for its ability to reduce assessment anxiety while maintaining academic rigour.
- Competence Acquisition: The EER effectively validates the acquisition of specific technical skills and transversal competencies.
- Sustainability: The design is economically viable and easily replicable in standard university settings. Future iterations could consider expanding the scope to include wet-lab elements or adapting the narrative to other pathogens, supporting the wider adoption of gamification to train adaptable scientists.

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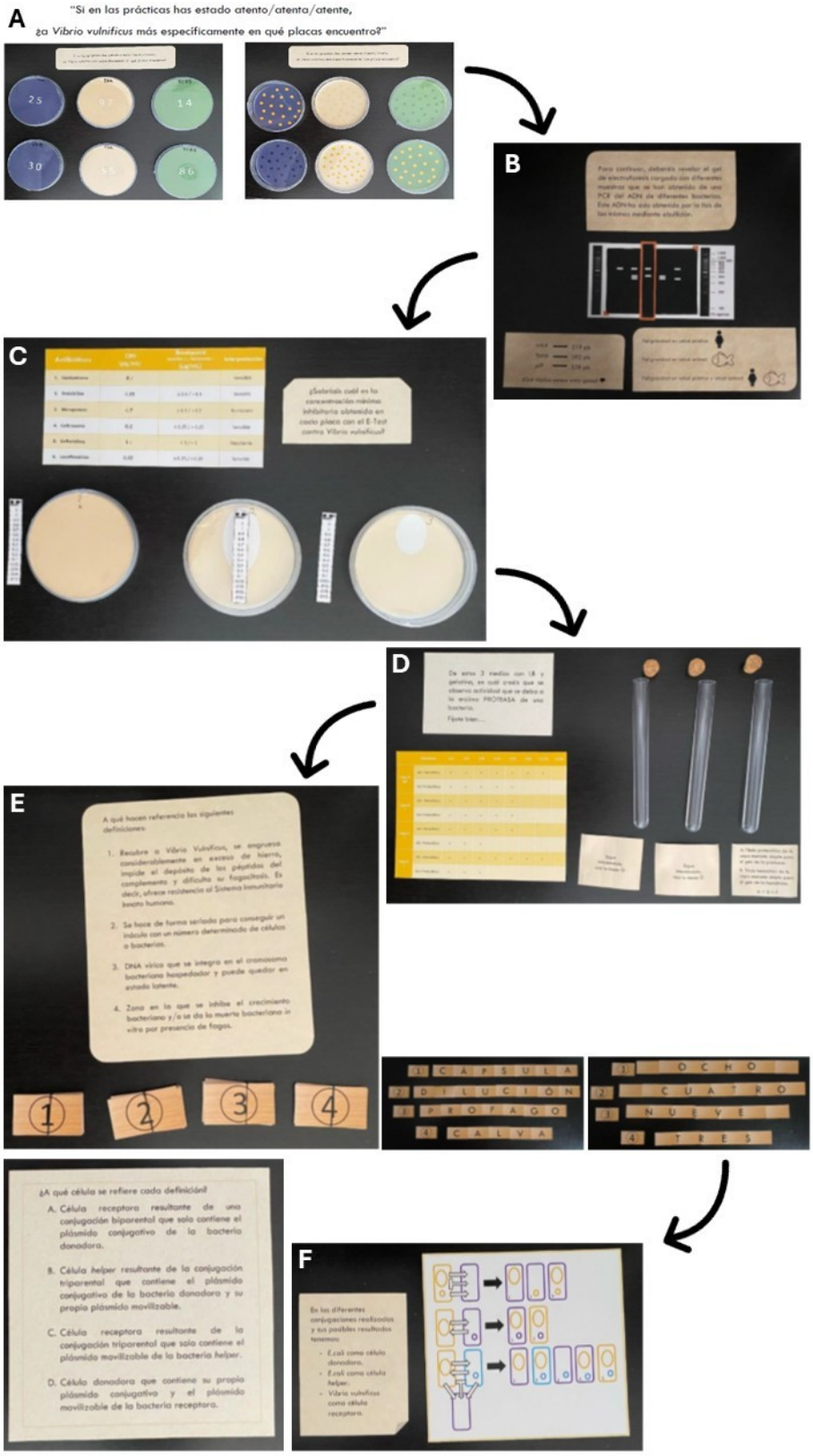
Figure 1. Sequence of the challenges developed during the Educational Escape Room A: First challenge consisting of the identification of the selective and differential media plates used for the isolation of V. vulnificus with its characteristic growth. B: Confirmatory test using multiplex PCR, in which the hazard to animal or human public health is analysed. C: Epsilometry for the analysis of the minimum inhibitory concentration of the isolated pathogen. D: Enzymatic assay to study the gelatin hydrolytic capacity of the isolate. E: Four questions related to aspects of the practical sessions or characteristics of the pathogen that the students must answer. F: Final challenge in which the knowledge acquired regarding triparental conjugation is demonstrated.



INTEGRATING SUSTAINABLE E-WASTE MANAGEMENT INTO THE SCHOOL CURRICULUM: A RESPONSE TO LIMITED INSTITUTIONAL SUPPORT

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Abstract

The growing demand for integrating technology into education has introduced effective teaching and learning strategies, aligning with the United Nations' Sustainable Development Agenda 2030. The intensifying digitalization of basic and higher education has accelerated the turnover of electronic devices, producing growing stocks of unused, obsolete and broken equipment at schools and education offices. Electronic devices used in education institutions are frequently replaced due to software and hardware upgrades or their short life span. This results in an increased intake of new devices without proper disposal of old or unused ones, leading to a rise in electronic waste (e-waste). A qualitative explanatory case approach was employed to gather data through individual interviews with asset managers or ICT teachers/specialists from four schools, three district offices and one provincial education department on how unused or broken electronic devices are managed or discarded in schools. Despite the health and environmental risks of unsound e-waste handling, findings revealed that there was no institutional plan for sustainable e-waste management. As a result, most institutions store devices for years or hire ad hoc private collectors. Furthermore, there was no support from other educational stakeholders to address this issue. This study showed how policy–practice gaps and resource asymmetries shape disposal behaviours. The implications are that the accumulation of e-waste and the use of unsustainable disposal methods will persist, leading to further challenges. This study therefore proposes a theoretical frame that combines Education for Sustainable Development (ESD) competencies, Institutional Theory (coercive/normative/mimetic pressures), and a Circular Economy/EPR (Extended Producer Responsibility) lens. We recommend (1) embedding e-waste across the curriculum (Grades R–12) with assessable competencies; (2) establishing provincial/district take-back arrangements aligned to South Africa's EPR Regulations; and (3) funded support for under-resourced schools to avoid environmental harm.

Keywords: *Education for Sustainable Development (ESD), e-waste, institutional support, management strategies, school curriculum.*

1. Introduction

The fast integration of information and communication technologies (ICTs) into education has transformed teaching and learning worldwide. Laptops, tablets, interactive whiteboards, and projectors are increasingly viewed as critical tools for improving learner engagement and equipping young people to participate in knowledge-based economies. This transition involves not only replacing traditional teaching techniques but also improving the educational experience by making it more accessible, engaging, and personalised (Hemajothi & Kumar Jain, 2022; Kumbo et al., 2023; Murcia et al., 2018). However, technological advancement, upgrading, and increased demand for electrical and electronic equipment (EEE) have contributed to a decrease in the average life cycles of new computers, resulting in a significant reduction in their lifespan (Perkins et al., 2014; Moyo et al., 2020; Ichikowwitz and Hattingh, 2020), resulting in uncontrollable electronic waste. Electronic waste includes a wide range of electrical or electronic equipment that has reached the end of its useful life (i.e., is obsolete) and is no longer required by its owners (Moyo et al., 2020). It is one of the world's fastest-growing waste sources, driven by increased digitalisation and shorter gadget lifecycles. 44.7 million tonnes (Mt) of e-waste were generated globally by 2016 and climbed significantly to 53.3 Mt in 2019, translating to an average of 7.3 kg per capita (Forti et al., 2020). This growth is expected to reach a high level of 74.7 Mt (three to four percent growth each year) by 2050 (Forti et al., 2020; Ichikowitz and Hattingh, 2020), unless interventions are implemented to slow it. This means that e-waste has nearly tripled the rate of municipal solid trash worldwide (Samarakoon, 2014; Ichikowitz & Hattingh, 2020).

E-waste is acknowledged as a resource due to the possible recovery of precious materials such as iron, alluminium, copper, gold, silver, platinum, palladium, and rare metals from the periodic table's 69 elements (Heacock et al., 2016; Torres et al., 2016; Forti et al., 2020). However, it poses considerable environmental and public health risks due to its complex composition, which includes toxic compounds such as lead, mercury, and brominated flame retardants (Forti et al., 2020). Some governments strive to regulate e-waste. South Africa, for example, has implemented Extended Producer Responsibility (EPR) regulations under the National Environmental Management: Waste Act (NEM:WA) to require electrical and electronic equipment (EEE) manufacturers to fund collection and environmentally sound management (EPR Regulations, 2020, as amended 2021). Despite increased policy attention to sustainability and waste management, many schools, particularly those in historically disadvantaged and resource-constrained communities, lack the institutional support required to successfully integrate e-waste education into daily instruction.

Schools have a dual role in the e-waste challenge. On the one hand, they contribute to e-waste development through regular technological upgrades prompted by curriculum reforms, digital learning initiatives, and legislative demands. On the other hand, schools have an important role in influencing students' environmental awareness, beliefs, and behaviours. Rapid device turnover due to software/hardware obsolescence and digitisation imperatives exacerbates the situation of e-waste in schools. These institutions require institutional support such as leadership commitment, curriculum guidance, professional development, infrastructure for safe storage and disposal, and collaborations with accredited recyclers (Fullan, 2016).

Integrating sustainable e-waste management into the school curriculum provides a strategic opportunity to solve environmental issues while also improving educational goals such as citizenship, sustainability, and systems thinking. This achieves the Education for Sustainable Development goal of empowering learners to make educated decisions and behave responsibly for environmental integrity, economic viability, and a just society for current and future generations (UNECSO, 2017). This allows them to build information, skills, beliefs, and attitudes that will help them maintain long-term solutions to issues affecting their education and lives. This paper addresses this gap by investigating how sustainable e-waste management might be included into the school curriculum in environments with inadequate institutional support. The study focuses on South African schools and addresses the following research question:

How can sustainable e-waste management be integrated into the school curriculum in contexts with limited institutional support?

2. Methodology

A qualitative, explanatory case study approach was used to investigate how schools and education offices manage e-waste under present constraints. An explanatory case study is used to address a question about the hypothesised causal relationships in real-life interventions that are too complicated for survey or experimental methods (Yin, 2003). People who have faced issues related to e-waste management in schools can provide a more detailed explanation. Eight participants (asset managers or ICT teachers/specialists) were purposefully selected from four public township schools in underserved areas, three district offices where the sampled schools were located, and one education provincial office that served both the sampled schools and the district offices. Schools that provide either computer application technology (CAT), information technology (IT), or both topics were chosen because they have more technical tools than other schools. Two of the schools (A and B) were public and funded by the Department of Education, while the other two (C and D) were privately owned. One of the schools, B, is an ICT school of specialisation, with the majority of students taking IT and CAT. They sampled to determine how they disposed of their e-waste and the type of support they received. The district and provincial offices were sampled to determine their role in assisting schools in dealing with e-waste. Semi-structured risk displacement, concerns about data security, potential health risks, and perceived restrictions. Transcripts from interviews were coded to generate inductive themes. Institutional permits were secured; informed consent was gained; institutions and people were anonymised; no photos of serial numbers were captured; and a safety note was recorded where e waste burial was mentioned. Teachers were coded based on their schools.

3. Results

3.1. Inventory status

Table 1 below tabulates the number of digital resources that were available at the sample’s schools.

Table 1.

School	Number of usable technological resources	Type of technological gadgets
School A (public)	150	Desktop computers and Laptops, 3 printers, 5 data projectors
School B (public ICT)	1600	Photocopier machines, projectors, Teacher laptops, desktops
School C (private)	118	100 desktops , 2 projectors, 10 laptops, 5 printers.
School C (private)	43	40 computers, 3 photocopying machines

3.2. Awareness of policy

Findings indicated that there is no institutional plan across levels. Participants reported absence of formal plans at school, district, and provincial levels for sustainable e-waste management. District/provincial offices indicated that when their e-waste is removed, accredited companies transport to a central warehouse/facility, but schools are *not* included in that pipeline. Staff were unaware of any education-sector guidelines or standard operating procedures. For example, School B:School B teacher indicated that he was not aware of any policy guiding e-waste management. He said: *"No, we don't have such a policy".* District and provincial officials did not seem to know how they could assist schools.

3.3. Disposal practices of technological devises that are no longer in use

From the findings, public schools stored obsolete/broken devices for years due to perceived legal/liability barriers and lack of budget for removal, while private schools took their e-waste to formal recyclers or where they initially bought gadgets. **Teacher B** indicated that they didn't have a system in place for technological devises used for teaching on how to dispose unused technological devices. He indicated that they stored everything unused in a certain room, and some teachers kept their old and broken laptops in their offices. His response was : "*They just remain there. Then it's a matter of maybe we'll recycle them somehow or someone just takes them and put them somewhere in their office or something of that nature*". His frustration was that unused gadgets were piling and even though they were told that there will be arrangements to collect them and take them for recycling, this was not done for almost three years, causing storage challenges as other equipment broke or became outdated. However, since the school for **Teacher B** is an ICT school, he indicated that they are required to give an account of every gadget provided by the department of education, broken or in good condition. As a result, learner devices are always retrieved every year that is at the end of the year. So he supposed that suppliers took learers devises took the gadgets every year in order to upgrade them somehow, while they are given new upgrade learner gadgets every year. Nevertheless, where schools made a plan to get trid of e-waste, this information ws not accessibkle to the person allocated the responsibility of technonogy gadgets asset manager. When asked why they didn't take broken gadgets for recycling the teacher indicated that he does not make that decision, but he was never consulted about decision made. His response was: "*I remember last year we had a a bunch of computers in the computer that I'm currently using. I'm not sure how they dispose those. They're very old computers and they were not working. So I'm not 100% sure what they actually did with those computers".*

Private schools did not have challenges with storage since they solved their e-waste challenges. **Teacher B** indicated that they didn't have a system in place for technological devises used for teaching on how to dispose unused technological devices. He indicated that they stored everything unused in a certain room, and some teachers kept their old and broken laptops in their offices. His response was : "*They just remain there. So otherwise then, yeah, they just remain there. Or otherwise then it's a matter of maybe we'll recycle them somehow or someone just takes them and put them somewhere in their office or something of that nature".* His frustration was that unused gadgets were piling and even though they were told that there will be arrangements to collect them and take them for recycling, this was not done for almost three years, causing storage challenges as other equipments broke or became outdated.

3.4. Risk displacement, data security anxieties and possible health hazards

One of the fears that led to prolonged storage of technological devises was data breaches from discarded devices which led them to retaining technological equipment in schools indefinitely—compounding storage hazards. Using classrooms as storages because of lack of storage rooms was also a source of concern. The challenge with storing e waste affected the other activities in the school and presented a potential health hazard for teachers and learners. **In school A**, the teacher mentioned that it would assist if he knew what to do with e-waste on time, because they present a challenge of space.

His response was: "*Really, though, we don't have space for them. Because for instance, those devices that I was speaking about that were disposed last year, they had been there for quite some time and no one really actually knew what to do with them. Some teachers were actually using the classroom to teach so it was it was that the challenge of srorage".* This practice conflict with health guidance on toxic constituents and exposure pathways. Additionally, in communities where crime is rife, when unused technological gadgets are stored at school, they may attract thieves. **Teacher B**'s response was: "*if we keep them for too long, they end up being damaged or they end up being vandalized. If unused gadgets are just sitting there, they end up attracting thieves*".

3.5. Perceived barriers

The lack of guidelines frustrated both schoolteachers and district officials which implied that schools had to continue with their struggles of lack of storage and exposure to hazards from e-waste. **Teacher A** indicated that he was not aware of the role of the district /provincial office regarding e-waste accumulating at their school, but indicated that perhaps school managers knew since there would be removal of old and unused gadgets at certain times-although he was not aware of the procedures followed, despite his allocated duties as an ICT asset manager at the school. He also indicated that he didn't ask what happened with the e-waste. For private schools, electronic waste was costly for them since they didn't receive any assistance from the department of Education. **Teacher C** indicated that the challenge in their school was the frequent upgrading of sofwares, which is costly for them since they are not funded by the department of Education. He said: *"The technology that changes every two, three years. We have that challenge because we find that we purchase computers, then they tell us after two or three years, the windows change. Like for 2025, they said as of October, Windows 10 is no longer going to operate, and now we are faced with a serious challenge where we must make sure all the computers have Windows 11. And also pertaining to the upgrades of those desktops, we need to upgrade all of them so that they can be able to use Windows 11. It affects the school financially because we have to make sure every desktop is up to date, and then it works on Windows 11".*

4. Conclusion and recommendations

The schools sampled for this study had adequate technology resources and required a competent e-waste management plan. This study identified deficiencies in e-waste management in schools, with no assistance from district and provincial offices. Private schools that did not receive funds from the department of education did not have to account to anyone or ask for authorisation to dispose of their e-waste, therefore they got rid of it sooner than public schools. Despite a national EPR framework, schools suffer a support gap: without sector-specific guidance, operational arrangements, and equity-minded financing, they rely on storage. While the curriculum and assessment policy statement (CAPS) might include e-waste management into the curriculum, this is not the case, and schools are not prepared to do so. There does not appear to be a solution for e-waste management in the near future, nor is there any intervention or preventive strategy that could benefit all schools simultaneously. Embedding ESD-aligned e trash education and developing producer-funded collection routes can help to reduce the policy-practice gap, safeguard health, and model circularity for future decision-makers. As a result, this study suggests that schools adopt and monitor e-waste management policies and system activities. A longitudinal follow-up study should also be conducted (three years after the guidelines are implemented) to assess changes in stocks, procedures, and health/safety issues. This can be accomplished using a theoretical framework that blends ESD competences, Institutional Theory (coercive/normative/mimetic pressures), and a Circular Economy/EPR perspective. E-waste management should also be integrated into the curriculum (Grades R-12) with assessable competencies, and the province/district should ensure that the South African EPR Regulations are applied and monitored in schools. Furthermore, to avoid environmental damage, under-resourced schools should receive subsidised support.

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AI-ENABLED DESIGN PIPELINES AND THEIR IMPACT ON TEACHING PRACTICE

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Abstract

Artificial intelligence is restructuring design workflows by automating tasks that traditionally required substantial human expertise. These changes are accelerating the need for existing design training systems to adapt to new methods since they were developed on the premise of linear processes and manual skill acquisition. This paper presents a review of the current state of AI-assisted design and its impact on teaching practice. A design case is selected to demonstrate in detail how text-based prompts are transformed into visual patterns, digital fabrics, and ultimately digital garments, featuring virtual fittings, still images, and even video outputs, all ready for direct market release. Each part of the process exemplifies a mode of computational delegation that shortens the production time and alters the notion of authorship. While such workflows expand creative reach, they also raise critical questions for educators regarding control, evaluation, and the preservation of human creativity. The review recommends that educators should not be averse to technological changes, but instead, they should integrate programmed reflections on the pros and cons of AI to empower students to use these systems effectively without compromising their creative agency. The paper aims to provide ways for curriculum updating, adaptive expertise development, and designers' preparedness for a rapid professional environment change through analyzing new AI workflows and their impacts on teaching.

Keywords: *AI-enabled design, digital workflow, design education, teaching practice, creative agency.*

1. Introduction

Artificial intelligence has progressed from being a supportive computational resource to an active collaborator in the creative process. In the field of design, the role of AI has expanded from mere optimization and automation in isolated phases to full engagement throughout the production pipeline, hence changing the order of things in idea generation, development, visualization, and delivery to the market (Boden, 2016; McCormack et al., 2019). This transition has far-reaching effects on design education, which has so far been based on the linearity of the workflow and the gradual acquisition of technical skills. Most existing design curricula are structured around the idea of students progressing through levels, from concept creation to production and final presentation. Even if the models depict past production situations, they are becoming increasingly out of tune with the professional world, where AI-assisted systems often shrink or skip several stages of production. Thus, students may be trained to have technically proficient but poorly adapted skills to the current workflow, which in turn increases the distance between education and industry practice.

This paper aims to fill the gap created by the above scenario by analyzing the potential impact of AI-assisted design pipelines on teaching practices. The paper not only highlights the positive aspects of AI usage but also outlines the implications of this case study regarding the evaluation of past and traditional fashion design workflows that can be transformed into AI-native workflows. Through a detailed case study, the paper examines how. The goal is not to recommend a particular software platform but rather to consider this case study as a practical viewpoint through which one's broader educational and knowledge implications can be discussed.

2. From AI tools to AI agents

To understand the transformation of design workflows, it is essential to distinguish between AI tools and AI agents. Many AI applications used in design processes today work as reactive tools. They

perform specific tasks, such as image processing or color control, in response to direct user input. The designer is always responsible for combining results and organizing the process.

In contrast, AI agents are more proactive and goal-driven systems that operate autonomously within a specific environment. Instead of merely performing one task, an agent may engage in diverse tasks to accomplish a broader goal, while flexibly making decisions that are unknown to the agent to reach that goal. This duality has been a topic of great importance in AI research, where an agent is characterized as a setup in an environment that perceives and acts (Russell & Norvig, 2021).

According to a human-centered orientation, this change, of course, invites important questions regarding control and responsibility. Shneiderman (2022) has further explained that mechanisms that require human control are critical, particularly in creative and cultural domains. In design education, this implies that students must learn not only how to operate AI agents, but how to direct, evaluate, and constrain them.

3. Traditional design workflows and educational assumptions

The traditional fashion design process has always been a linear one, with a series of steps to be followed. From research and conceptualization, the designer would then proceed to pattern making, followed by visualization after completing the fabric design, garment construction, and fitting. Each process stage has its own set of skills, and transitioning from one stage to another typically requires a significant investment of time and resources.

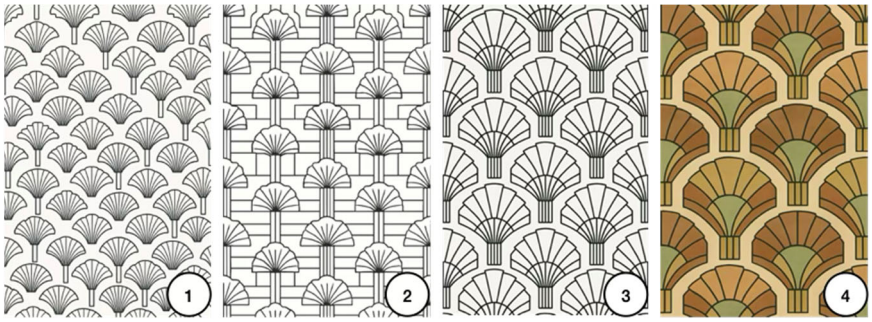
Educational models draw inspiration from this layout. Courses are typically organized by skill type, such as illustration, textiles, pattern making, photography, and video production. Such an organization facilitates the gaining of in-depth knowledge, but at the same time promotes a fragmented view of the overall workflow. Research in design education has found that such compartmentalization can undermine students' ability to integrate knowledge across stages (Kolko, 2010).

On the other hand, the advent of computational design systems is slowly but surely changing these assumptions. According to Oxman (2017), design with computers opens up non-linear movements that are feedback-driven and require different design thinking. When AI systems can carry out tasks such as generating patterns, simulating materials, and producing lifelike visualizations within a few minutes, educators need to reassess the importance of protracted manual execution.

4. Case study: An AI-Native workflow using Style3D AI functions

The case examined in this paper demonstrates an AI-native workflow implemented through the Style3D AI+3D ecosystem. The process begins with text-based prompts authored by the designer, describing aesthetic intentions, references, color palettes, and material characteristics: "Geometric abstract mushroom pattern, symmetrical fan-shaped caps with stepped edges, vertical linear stems, radiating line details, clean black and white linework, structured repetition, grid and band-based layout, seamless and orderly, minimal and elegant." These prompts are processed by the Style3D Moda - Graphic Design Agent, which generates corresponding graphic patterns (Fig. 1-1). In most cases, the initially generated output does not fully align with the designer's vision (Fig. 1-2). Therefore, the text prompt needs to be carefully refined and iteratively adjusted through multiple attempts until the ideal result is obtained (Fig. 1-3). After several attempts, the designer arrived at the ideal black-and-white pattern and then asked the AI to "color this pattern using tones inspired by mushrooms found in nature" (Fig. 1-4). Unlike traditional digital textile design, where designers manually construct repeats and colorways, the AI agent rapidly produces multiple variations. The designer's role shifts toward prompt refinement, selection, and conceptual evaluation. This stage exemplifies computational delegation, where technical execution is largely automated while creative direction remains human-led.

Figure 1. The designer iteratively refined the initial text prompt to achieve a satisfactory final pattern.



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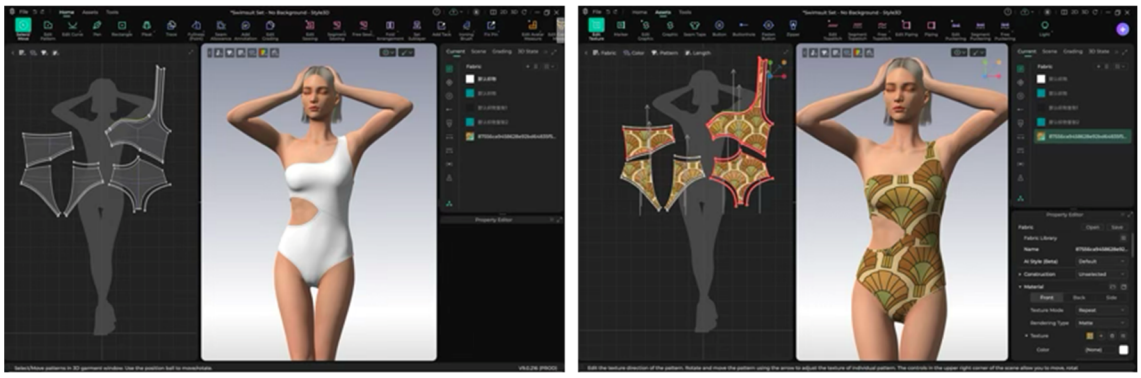
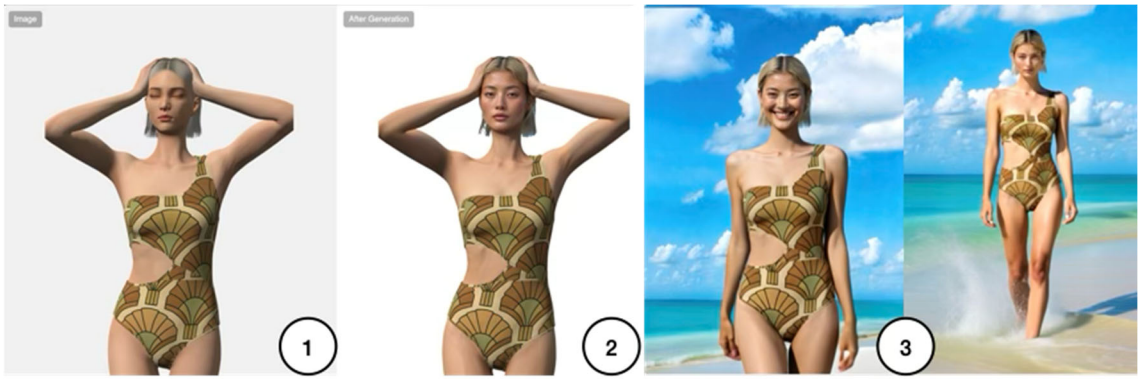
The generated colored pattern file is then imported into Style3D Studio and applied directly to digital garment designs. In this case, the designer selected a women's swimsuit from the Style3D cloud database and applied the previously generated pattern (Fig. 1-4) to the existing 2D pattern, replacing the original white fabric (Fig. 2). Garment silhouettes and fabric behaviors are adjusted within the same environment, allowing immediate assessment of fit and drape in 3D window, avoiding the repetitive phisical sampling process commonly required in traditional workflows.

Figure 2. In Style3D Studio, the generated pattern is applied to the chosen garment.



After finalizing the 3D design and making refinements, the designer leveraged a new AI-assisted image generation feature, AI Snap. Instead of traditional rendering processes, which are often time-consuming and yield limited realism (Fig. 3-1), AI Snap generates marketing-ready images featuring highly realistic human models (Fig. 3-2). These images can be produced with minimal setup and are suitable for immediate commercial use. In the final stage, still images are used as inputs for the Style3D Moda - Style to Video function. Through additional text prompts that describe motion and atmosphere: "I want the model to walk out of the sea on a beach in the Maldives, showcase the outfit, then turn around once and walk back into the water, the overall mood should be enjoying the beautiful seaside scenery," a short marketing video is automatically generated in few minutes (Fig. 3-3). The entire pipeline, from concept to video output, can be completed in a fraction of the time required by traditional workflows, fundamentally altering the temporal and cognitive structure of design practice.

Figure 3. Marketing-ready images and videos generated using AI Snap and Style3D Moda - Style to Video functions.



5. Authorship, creativity, and computational delegation

AI systems have begun to play an ever-greater part in carrying out generative tasks, and thus, authorship conceptions start to wobble more than ever before. When patterns, materials, images, and videos are produced through coordinated AI agents, creative ownership becomes distributed across both human and machine actors, rather than residing in a single, identifiable author. Manovich (2019) sees this as a sign of contemporary software-driven culture, which not only combines but also obscures the intent of individuals and the structures, defaults, and affordances embedded in computational systems that influence outcome creatively.

The shift toward AI-enabled workflows is best illustrated by the notion of computational delegation. Delegation is not a matter of replacement, and human creativity still plays a significant role, but now it is shared among the team, with each member assigned a different part to work on. AI is taking over

technical execution, variation generation, and even visualization, but humans still are the ones who determine the problems, set the constraints, and judge the outcomes. This split of responsibilities is challenging the educational models that are based on the assumption that authorship is equivalent to manual production or technical skill. In such cases, the designer's role is not so much to manufacture artifacts as to direct the processes and make well-informed decisions.

The ethical and educational dimensions present in this redistribution of roles create a scenario where issues of originality, accountability, and assessment arise. Floridi and Sanders (2004) contend that artificial agents become involved in moral and creative processes through which they demand new evaluative frameworks, especially when the sharing of agency is involved rather than the clear assignment of it. In design education, this means that traditional assessment methods, which favor visible labor and craftsmanship, are no longer adequate.

Instead, the teaching practice needs to be changed to evaluate decision-making processes, articulate intent, and engage in critical reflection on AI-generated outputs. Students should be evaluated on their ability to provide reasons for their prompt choices, identify limitations or biases in AI systems, and take action if the results produced conflict with their concepts or ethical intentions. If such a change doesn't happen, there is a possibility that the AI-assisted work will be considered either as unearned automation or as unquestioned authorship, both of which will eventually degrade educational rigor.

In terms of reframing authorship as a conceptual rather than a manual task, the design education can take advantage of human creativity and, at the same time, recognize the reality of computational delegation. Reframing does not mean that the designer's role gets diminished, but rather that it positions creativity on a higher level of abstraction where critical judgment, responsibility, and intentionality are still very much human competencies.

6. Implications for teaching practice

AI-native workflows are questioning the current pedagogical models in different fundamental aspects. The most critical effect of this is that they shatter the main assumption of linear skill progression, which is the foundation of much design education. The traditional curriculum expects students to progress gradually from basic exercises to complex projects, building on the technical proficiency they have gained. However, in the context of AI-native, students can create complex, ready-for-market outputs even at the very beginning of their training. This does not necessarily mean that the person has mastered the skill in the traditional sense; however, it does create a problem regarding the long-standing classifications of beginner and advanced work and causes educators to take a new look at how learning progress is formulated and measured.

Another issue relates to the evaluation of learning outcomes. The use of AI tools in the design process necessitates the creation of criteria for evaluation that take into account not only the quality of the output but also the quality of the process. Studies on reflective practice have shown that learning outcomes are strongly related to a person's ability to articulate reasoning, justify decisions, and evaluate alternatives (Schön, 1983). When AI systems contribute significantly to visible work, these cognitive and reflective capacities become even more crucial. Hence, assessment must focus on how students define their problems, how they create prompts, how they choose among the generated options, and how they adjust their paths based on the results.

The speed of AI-enabled production introduces a third pedagogical challenge by altering reflective cycles. Rapid iteration can significantly enhance experimentation and exploratory learning, allowing students to test ideas that would previously have been constrained by time or technical barriers. At the same time, such speed carries the risk of superficial engagement, where students accept generated outputs without sufficient critical scrutiny. To mitigate this risk, educators must intentionally incorporate structured reflection into their coursework. This includes requiring students to document prompt iterations, explain why certain results were accepted or rejected, and identify limitations or biases present in AI-generated outputs.

Most importantly, the adoption of AI-native workflows in design training does not mean relinquishing basic knowledge. The practitioner's understanding of the materials, form, proportion, and visual language remains crucial for a thorough evaluation of the AI systems and their effective guidance. Those fundamentals have to be reframed, though, in today's production environments, where execution is no longer the primary learning site. Thus, foundational knowledge is increasingly being perceived as a characteristic of the critical judgment process rather than a goal in itself.

AI-native workflows demand a shift in educational priorities from training specific tools to developing adaptable expertise. The educational system must prioritize important skills that will remain relevant as software continues to evolve, rather than just teaching students to handle fixed software interfaces. Students should be placed in positions of system ownership rather than merely being users of

tools. In design education, this means that prompt literacy, system-level thinking, and evaluative judgment will be regarded as the core competencies. Therefore, students will be able to navigate and influence the rapidly evolving AI-powered design environments with confidence and responsibility.

7. Conclusion

The pipeline for AI-enabled design suggests a significant shift in the creative process, rather than just a technological improvement. The example of Style3D demonstrates how AI-enabled processes break down the usual separation of design, visualization, and marketing, resulting in the modern market receiving output with exceptional speed. This upheaval in teaching practice necessitates the transition from tool-centered instruction to workflow-centered education. Design educators must not resist or automatically adopt AI systems but rather integrate them into curricula through reflective and structured pedagogical strategies. By keeping control sharp and emphasizing human creativity as a conceptual leadership over manual execution, education will not only remain relevant but also equip students with the tools necessary to navigate and even shape the rapidly changing professional environments.

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TEACHERS' EXPERIENCES CREATING TEACHING MATERIALS AS A TOOL FOR TEACHERS' LITERATURE TRAINING

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Abstract

Help students develop into future teachers who are prepared to take learners' needs into account. Provide innovative teaching and learning resources as part of the professional development requirements for student teachers. The scarcity of reading materials is one of the biggest issues in many rural and township communities. It is challenging for teachers to establish a productive learning atmosphere when this is the case. Every learner should have access to all the books and resources necessary to spark their interest in reading. In cases where reading resources are scarce, teachers ought to produce as many of them as they can. Therefore, to educate teachers for their future jobs, instructional material design is essential. The purpose of this study was to evaluate teachers' proficiency in creating resources. Fifty B.Ed. Foundation Phase II second-year students from Central University of Technology's Department of Educational and Professional Studies in South Africa participated in this research. “Participants were purposively selected, and their performance as student teachers was assessed using a marking rubric and structured classroom observations. To create their own Big Book, students were told to see videos on YouTube that demonstrated the process. The creative idea generation from the YouTube technique was explained to students, showing them how to use it and enhance students’ creativity for their idea generation. The results of the study demonstrated that using YouTube video technique helped students generate creative ideas to design a big book for future use. This means that instead of depending on the Department of Education's reading materials, student teachers should be encouraged to create their own to promote and improve future teaching-learning outcomes and make learning more engaging and pleasurable for learners. To prepare students for the workforce, the new study suggests that higher education institutions' instructors should foster a culture that encourages critical thinking, greater research, and creative thinking. The suggestion is to include opportunities for creativity in the lessons one teaches: To create their own Big Book, students were told to see videos on YouTube that demonstrated the process. The first step in this research was creating a marking rubric for each student to assess their level of creativity. The researcher in this study employed a statistical strategy to analyze quantitative data. It was discovered that most students could create books and other educational materials; some of them had trouble finishing large books for a variety of reasons. This means that instead of depending on the Department of Education's reading materials, student teachers should be encouraged to create their own to promote and improve future teaching-learning outcomes and make learning more engaging and pleasurable for learners. To prepare students for the workforce, the new study implies that higher education institutions' instructors should foster a culture that encourages critical thinking, greater research, and creative thinking. The suggestion is to include opportunities for creativity in the lessons one teaches.

Keywords: *Big Book, experiences, foundation phase students, student teachers, teaching materials.*

1. Introduction

South African rural and township primary schools continue to face challenges due to a lack of engaging and reading-level-appropriate materials to support young learners’ literacy development. The scarcity of appropriate resources creates a significant obstacle for teachers striving to cultivate effective learning environments and to meet the diverse needs of their learners. Consequently, fostering reading proficiency within primary education remains a critical issue. Teachers play a central role in promoting early literacy by implementing effective pedagogical strategies and using relevant instructional resources. The use of suitable and engaging materials is essential for enhancing students' reading abilities and establishing a culture of reading (Rohani, 2020; Nurrita, 2018). When such resources are limited or unavailable, teachers must rely on their own creativity and expertise to design and produce appropriate teaching materials.

In the twenty-first century, technology has become an important tool in teacher education and professional development. Students in higher education are expected to develop competencies such as critical thinking, problem-solving, collaboration, and creativity. Integrating technology into the curriculum supports these competencies by providing access to multimedia resources, including videos, simulations, and interactive activities, which enhance engagement and learning (Pink, 2018). Online platforms also allow students to learn at their own pace and explore new knowledge and practical skills (Pink, 2018).

Student-centered learning is closely linked to these technological developments. This approach emphasizes active participation, engagement, and learner autonomy, shifting away from traditional teacher-centered methods (Dayagbil et al., 2021). Technology further supports student-centered learning by enabling flexible and personalized learning experiences, allowing learning to occur anytime and anywhere (Maitra, 2007; Francl, 2014; Lai et al., 2018). Despite these advancements, traditional teaching methods are still widely used and may not adequately prepare learners with the skills required in a rapidly changing and interconnected world. Innovative approaches that foster critical thinking, self-directed learning, and reflective practice are therefore needed (Almazroa & Alotaibi, 2023).

This study examines teachers' experiences in developing their own instructional materials, particularly Big Books, as a means for literacy instruction and professional development. By involving student teachers in creating instructional materials, the study aims to enhance creativity, teaching skills, and readiness for future classroom situations. The primary objective is to investigate teachers' experiences in designing instructional materials for literature education and to assess how this process contributes to their professional growth and ability to support students' reading skills.

2. Literature review

2.1. Big Books as instructional materials in early literacy

Big Books are widely recognized as effective tools for supporting early literacy development. These oversized storybooks typically include large print, short sentences, and colorful illustrations, making them ideal for shared reading in classrooms (Rofiaha et al., 2021; Megawati & Wulandari, 2017). Their size ensures that all learners can clearly see both text and images, which is particularly useful for group reading activities (Mahayanti et al., 2017). Features such as large fonts, vivid illustrations, and simple or predictable storylines help learners connect visual cues with the meaning of the text (Khasana & Wibawa, 2019). These elements not only support comprehension but also encourage greater participation during reading. The combination of visual and textual features can also enhance vocabulary development for early learners.

Big Books are especially suitable for beginner readers because they use simple language structures and short sentences aligned with developmental levels (Madyawati, 2016). Large print and supportive illustrations help learners follow text more easily and build confidence in reading. Some studies suggest that Big Books may even be more effective than standard-sized books for vocabulary acquisition, as all learners can engage with the same text simultaneously (Kusuma Dayu & Setyaningsih, 2022). Although originally designed for early childhood education, their use has extended into the early primary grades, where visual support and interactive features can foster positive attitudes toward reading (Prawiyogi et al., 2021; Tatminingsih, 2022). However, their effectiveness depends on the context in which they are used.

2.2. Teacher-created materials and resource constraints

Big Books are particularly valuable in contexts with limited access to age-appropriate reading materials. In many developing education systems, including rural and township schools, shortages of engaging books remain a barrier to improving literacy outcomes. Surveys such as the Innovation for Indonesia's School Children (INOVASI, 2017–2018) highlight this challenge.

Figure 1. Illustrative examples of Big Books produced by student teachers demonstrating design and content features.

In response, teacher-created instructional materials have gained importance. Collaborative efforts among teachers, local governments, and organizations have facilitated the development and distribution of Big Books in underserved regions, such as East Nusa Tenggara and Sumba Island. These initiatives not only provide learners with access to reading resources but also empower teachers to create contextually

relevant materials. Designing their own instructional resources allows teachers to tailor content to learners' linguistic, cultural, and educational needs while fostering creativity, innovation, and professional growth.

2.3. Technology integration and student-centred learning

Technology integration has further expanded opportunities for developing instructional materials like Big Books. Modern teaching approaches emphasize student-centered environments where learners actively engage with the content rather than passively receiving information (Lai, Hsiao, & Hsieh, 2018). Digital platforms, including video-sharing tools and online resources, support student teachers in creating teaching materials. Instructional videos, for example, can guide learners through Big Book development, providing practical skills in material design (Bragg et al., 2021).

Technology also supports flexible, personalized learning, allowing student teachers to learn at their own pace and explore innovative strategies (Ross, 2011). The combination of hands-on creation and technology fosters an interactive learning environment, which is critical for preparing teachers for contemporary classrooms. Although Big Books and teacher-created materials are known to support early literacy, limited research has explored student teachers' experiences in creating these resources during their professional training. Similarly, technology's role in facilitating practical teaching material development warrants further exploration. This study addresses these gaps by examining how student teachers engage in Big Book creation and how this hands-on process contributes to their professional growth.

3. Research design

This study employed a quantitative research design using statistical methods to analyse student teachers' competencies in developing materials and arranging classroom environments. This design allowed for objective assessment of performance and skills, providing clear insights into the effectiveness of practical, hands-on training.

4. Objectives of the study

The primary objective was to assess the proportion of student teachers who could design and produce Big Books effectively to enhance learners' reading skills.

Additional objectives included:

- Assessing student teachers' creativity in developing teaching materials.
- Evaluating competencies in classroom environment layout.
- Determining overall performance using a structured marking rubric.

5. Methods

5.1. Participants

A total Fifty (n=50) second-year Bachelor of Education (B.Ed.) Foundation Phase student teachers from the Department of Educational and Professional Studies at the Central University of Technology, South Africa, participated in the study. specifically, 30 female and 20 male participants were purposively selected, reflecting the gender distribution of the program, with twenty male and thirty female students.

5.2. Data collection and procedure

Data were collected through classroom observations and a structured marking rubric to evaluate Big Book projects. Students worked in groups to design and produce their Big Books. A YouTube video demonstrating the creation process was provided, and rubrics were shared in advance to clarify assessment criteria, including creativity and design quality.

Students were briefed on the study's purpose and task requirements. They watched instructional videos and applied their learning to develop Big Books. All performances were treated confidentially to maintain a supportive learning environment.

5.3. Data analysis

Quantitative analysis was used to evaluate student teachers' competencies. The percentages determined performance levels in material development and classroom environment layout.

6. Results and analysis of students' performance based on the scoring rubric

Regarding Table 1, fifty participants created design big books and submitted them together with their evaluation rubrics. Participants' characteristics are shown in Table 1. For this study, thirty (n=30) female and twenty (n=20) male student teachers participated, as women make up the majority of the program's foundation phase, with fifty students in all (n=50). Thirty (0.6%) of the participants were female, while the fewest (20 (0.4%)) were male.

Table 1. Sample distribution according to gender.

Gender	Number	Percent %
Male	20	0,4
Female	30	0,6
Total	50	100

Table 2 shows students' performance on the question in terms of 1-10 items. This includes results of percentage.

Table 2. Students' Performance Based on the Scoring Rubric.

No	Assessment Criteria	Rating (1–5)	Number of Students	Percentage (%)
1	Is the cover both eye-catching and educational??	4	9	18%
2	Are the font size and type used suitable for the students?	4	7	14%
3	Are the sentences brief for the students' level?	5	7	14%
4	Is the reading level age appropriate?	5	6	12%
5	Will students find the text engaging enough to read?	5	4	8%
6	Are the topics and activities sufficiently covered?	4	2	4%
7	Are the subjects engaging and inspiring for students?	4	5	10%
8	Do the subjects encourage students to voice their own opinions?	4	2	4%
9	Is the design and arrangement suitable and understandable?	5	4	8%
10	Are the subjects realistic?	5	4	8%
	Total			

Results of Participants Based on the Scoring Rubric

The results from the scoring rubric highlight several important patterns in how student teachers performed when developing their Big Books. Overall, it is evident that participants were more confident in the technical and structural aspects of material development than in creating engaging, learner-centred content.

In terms of visual appeal, 9 students (18%) received a Level 4 rating for designing covers that were both eye-catching and educational. This suggests that many participants were able to apply basic design principles effectively to capture learners' attention. Similarly, 7 students (14%) showed competence in selecting appropriate font size and type, which plays a key role in supporting readability for young learners.

Looking at language use, 7 students (14%) achieved the highest rating (Level 5) for writing sentences that were brief and suitable for the learners' level. In addition, 6 students (12%) ensured that the reading level of their texts matched the age of the intended learners. These findings indicate that most participants have a good grasp of foundational literacy principles, particularly in adapting content to suit learners' developmental needs.

However, the results also show weaker performance in areas related to learner engagement and critical thinking. Only 4 students (8%) created texts that were engaging enough to capture learners' interest, while 5 students (10%) developed topics that could be considered inspiring. More notably, only 2 students (4%) designed activities that were sufficiently developed or that encouraged learners to express their own opinions. This points to a limited ability to move beyond basic content creation towards more interactive and learner-centred approaches.

In addition, only 4 students (8%) achieved the highest rating for the overall design and organisation of their Big Books, as well as for ensuring that the content was realistic. These elements are important because well-structured and relatable materials can significantly enhance learners' understanding and connection to the content.

Taken together, the findings reveal a clear trend. While student teachers are generally capable in areas such as design, readability, and age-appropriate writing, they experience challenges when it comes to incorporating engagement, interactivity, and opportunities for critical thinking. This suggests a need for teacher education programmes to place greater emphasis on developing creativity and supporting student teachers in designing more learner-centred materials.

7. Discussion

The findings highlight the value of practical, hands-on experience in teacher education. Creating Big Books allowed student teachers to apply theoretical knowledge while engaging creatively. Many students demonstrated increased confidence in designing materials, experimenting with illustrations, and arranging content to engage learners effectively.

Digital tools, such as YouTube instructional videos, enhanced learning by offering step-by-step guidance and allowing self-paced exploration. The combination of hands-on creation and digital support provided a safe space for experimentation, enabling students to refine their skills without fear of failure.

Overall, producing Big Books bridged theory and practice. Students developed practical teaching skills, reflected on their competencies, and gained a deeper understanding of how well-designed materials can foster literacy development. The process also encouraged creativity, problem-solving, and reflective practice, all critical for future classroom success.

8. Conclusion and recommendations

The results of this research show that guided material development is a powerful approach to strengthen student teachers' professional skills. Creating Big Books helped participants develop creativity, critical thinking, and practical teaching abilities, while increasing confidence in supporting learners' reading development.

The findings suggest that teacher education programs should integrate hands-on material creation into their curricula, allowing student teachers to connect theory with practice. Digital resources and instructional videos should also be incorporated to provide flexible, step-by-step guidance. Additionally, schools and training institutions should support teacher-led creation of instructional materials, particularly in resource-limited contexts, to ensure culturally and developmentally relevant materials are available.

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LET ME SHOW YOU SOMETHING – NOTIONS OF VIDEO-BASED ASSIGNMENTS IN UNIVERSITY

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Abstract

As video-based communication becomes an increasingly prevalent mode of expression in professional and academic contexts, higher education faces the challenge, and opportunity, of integrating multimodal production into its pedagogical practices (Navarrete et al. 2025). This paper examines master's students' experiences in a university-level course where two group assignments were completed and submitted in the form of short videos. Each group consisted of three students, collaborating to design, script, record, and edit their work. The study explores how students initially received the video-based assignment format, how they navigated the process of creating the videos, and how they reflected on the experience afterward. Drawing on students' reflections, in-class discussions, and observations collected during the project period, the analysis reveals a trajectory of their perceptions. The findings are triangulated through a questionnaire in the next few weeks. At the outset, students are expected to express uncertainty, some regarding their technical skills, others the perceived ambiguity of creative tasks compared to traditional written assignments. Despite this initial hesitation, groups quickly developed working norms and distributed roles and tasks, maybe according to individual strengths, indicating that video production naturally encouraged collaboration, negotiation, and peer support (Campbell & Cox, 2018; DeLange, 2020). Whilst at least partly having a good time. During the production phase, students are also expected to report a heightened sense of engagement and ownership. The performative nature of video prompted deeper internalization of content, as groups sought to communicate ideas clearly and compellingly. The iterative process of scripting, recording, and editing further required students to agree upon the central concepts and make deliberate mutually agreed design choices, fostering critical reflection on the subject matter. Challenges, such as time management, diverging creative visions, and technical constraints, are likely to have emerged as meaningful learning moments as well as hindrances along the way. Post-assignment reflections are anticipated to show that students valued the authenticity and variety introduced by video-based assessment. There may be feelings of accomplishment and format enabled expressions of insight and creativity that written submissions often constrain. Students have indicated that the assignments felt more aligned with the communicative demands of contemporary working life, increasing the perceived relevance of the course. The findings suggest that short video assignments can enrich learning by promoting collaboration, creativity, and conceptual understanding. The paper concludes with recommendations for instructing video-based tasks that balance structure and openness, support equitable participation, and support students' technical and creative development.

Keywords: *Video-based assignments, university assignments, student supporting.*

1. Introduction

Video-based communication has rapidly become an important mode of expression in professional, organizational, and academic contexts. Meetings, project updates, onboarding, teaching, and even assessments increasingly rely on audiovisual formats rather than exclusively written text (Khomyshak, 2024). As higher education is expected to prepare students for contemporary working life, this shift raises both challenges and opportunities for pedagogical design (Borghi et al., 2016; James, 2002). In particular, educators are prompted to reconsider how assessment practices might integrate multimodal and performative forms of knowledge expression rather than just using traditional written submissions alone (Navarrete et al., 2025). Thus, it may be concluded that newer winds are blowing.

Within this context, video-based assignments have gained attention as a means of fostering active learning, collaboration, and engagement (Noetel et al., 2021). Prior research has suggested that video production tasks can support deeper learning by requiring students to articulate ideas clearly, negotiate meaning collaboratively, and reflect on both content and form (Campbell & Cox, 2018; De Lange et al., 2020). At the same time, such assignments often introduce uncertainty for students, who may still be unfamiliar with creative assessment formats or concerned about technical competence, role distribution, and evaluation criteria (Nguyen, 2025). Understanding how students experience these tensions is therefore critical for designing effective video-based pedagogical practices to make the best of them.

This paper examines master's level students' experiences on a university course in which two group assignments were completed and submitted for assessment as short videos. Each group consisted of three students who collaboratively designed, scripted, recorded, and edited their outputs. Rather than treating video solely as a delivery medium, in this particular case the assignments positioned video production as a learning process that demanded collective sense-making, creative decision-making, and mutual responsibility. The study focuses on how students initially perceived the video-based assignment format, how they navigated the production process, and how they reflected on the experience after completing the tasks.

Empirically, the study draws on multiple qualitative sources, including students' written reflections, in-class discussions, and observations collected during the project period. These data are supplemented and triangulated with a questionnaire administered in the weeks following the assignments. Together, these materials allow for a process-oriented analysis of how students' perceptions evolved over time. Initial responses are expected to reveal hesitation and uncertainty, particularly related to technical skills and the perceived ambiguity of creative tasks compared to more familiar written assignments. As the work progressed, however, groups developed shared working norms and distributed roles, often aligning responsibilities with individual strengths. This suggests that video production can function as a catalyst for collaboration, peer support, and negotiated expertise.

During the production phase, students are anticipated to report heightened engagement and a growing sense of ownership over both the process and the outcome. The performative and public nature of video appeared to encourage careful consideration of key concepts and how they were communicated. Iterative cycles of scripting, recording, and editing required groups to agree on central ideas and jointly commit to design choices, thereby fostering critical reflection on course content. At the same time, practical challenges—such as time constraints, divergent creative visions, and technical limitations—emerged as both obstacles and meaningful learning experiences.

Post-assignment reflections indicate that many students valued the authenticity and variety introduced by video-based assessment. Feelings of accomplishment were commonly expressed, and students highlighted that the format enabled forms of creativity and expression that written assignments often constrain. Importantly, students also perceived the assignments as more closely aligned with the communicative practices of contemporary working life, which increased the relevance of the course in their view.

Overall, the findings suggest that short, group-based video assignments can enrich learning by promoting collaboration, creativity, and conceptual understanding as suggested by Cornock & Crombie. (Cornock & Crombie, 2021). By foregrounding students' lived experiences, this study contributes to ongoing discussions on multimodal assessment in higher education. The paper concludes by offering practical recommendations for designing video-based assignments that balance structure and openness, support equitable participation, and scaffold students' technical and creative development.

2. Design

The master's programme under scrutiny in this paper includes compulsory courses that build on foundational content typically covered in the bachelor's phase. Should one have already a suitable bachelor's degree, person may or may not have the necessary basics required for successful completion of the master courses. Having said that, the study program is rather packed. Because applicants may enter the master's programme with a bachelor's degree from another institution or discipline, some students may lack the prerequisite knowledge or 'know how' needed to complete the such master-level courses successfully. At the same time, the curriculum is tightly scheduled and leaves limited room for adding remedial acquisition of skillsets. The question arises how is this mode and opportunity perceived by the students and also partly commented by the staff.

The scrutiny in this paper observes a master stage course, business intelligence centered *Basics for Business Data Analytics*, which provides essential contents for master-level knowledge management studies. Under the standard delivery mode, *Basics for Business Data Analytics* is taught in the third term. The course entails seven lectures and weekly activities in addition to the case assignment given by an outside party, most often a business enterprise sought by the teacher responsible. The assignment is to be done in groups of three to four students, two groups solving each case. The students are to very independently approach the case but also independently to frame the assignment, obviously in accord with the case organization thus underlining proper communication. This is also mentioned as a learning objective. An example of an assignment is to position a business to its competitive surroundings by competitive analysis and benchmarking. In addition to this maybe make suggestions for further development of operation. This study examines how the independent assignment delivery per video was taken and perceived by students and how it is viewed by teaching staff.

Empirically, the paper foregrounds students' perspectives while also incorporating teaching staff reflections on the implementation. All 23 students in the study year 2025–2026 taking part on this particular course were invited to respond to a 32-item questionnaire comprising Likert-scale items (1–5) and clarifying open-ended questions. In addition, the two instructors responsible for the course were interviewed to contextualise the student responses and capture staff views on the arrangement. Owing to unanticipated factors, e.g. previous engagements, and scheduling constraints, only 18 students completed the survey. Nevertheless, the qualitative responses showed early signs of thematic saturation, providing initial support for the robustness of the observed patterns.

3. Background

The current Tampere University, and the very community, was established as the former Tampere University of Technology, University of Tampere, and Tampere University of Applied Sciences merged. The merger took with the year 2019 beginning. At the same time the ownership of the University of Applied Sciences was transferred from the city of Tampere to the newly formed Tampere University thus creating the community. The individual universities were founded in the 1960s, while the origins of the University of Applied Sciences date back even further.

The newly formed university encompasses nearly all internationally recognized fields of study in its seven faculties. The university has a strong focus on research and education in technology, health, and society. Tampere University is one of Finland's most versatile and multidisciplinary universities. The community includes approximately 32,000 students and over 5,000 staff members. The university operates on three main campuses in Tampere, Finland's third-largest city, and has three university centers in following cities: Lahti, Pori, and Seinäjoki. The purpose of the university centers is also to address the more localized needs of the areas mentioned.

This paper focuses on the teaching activities at the Hervanta campus, on which the former University of Technology resided, and which was primarily the domain of the more technical teaching and research. It is important to note that the university has made ever since the merger significant efforts to ensure uniformity across all campuses, so the observations in this paper are likely applicable at least to a degree to other parts of the university as well, even if the cultural difference between the campuses, e.g. between the humanities and electric engineering, is occasionally said to be there.

The daily routines of the teaching staff often include research work and research-related tasks, with few individuals being able to focus solely on one area, be it teaching or research. The pedagogical and didactic expertise of the staff varies, as many individuals come from research backgrounds. Similarly, the technical proficiency of staff members ranges from those who use basic tools like PowerPoint and PDFs to those who are adept with advanced features of learning platforms and AI tools. The tasks of the staff can be broadly categorized into teaching (the main focus of this paper), research, and administrative duties. The latter category is somewhat ambiguous, as it may or may not be connected to the other two areas.

4. Findings

As implied before, the students were expected to express uncertainty, some regarding their technical skills, others the perceived complexity of tasks demanding a novel kind of creative approach compared to traditional written assignments. Despite this initial hesitation, groups quickly developed working norms and distributed roles and tasks, maybe according to individual strengths, indicating that video production naturally encouraged collaboration, negotiation, and peer support.

All in all, the students' views on delivering videoed assignments varied from nerve-racking to pleasant change, even if the majority of the students have had previous experience of delivering videos on some individual occasion.

"*The video assignment felt like a pleasant change. Appearing on video comes naturally to me, so I was excited about the format*." *(Respondent 11)*

The students were enquired how did they felt when they experienced that the course assignments would be submitted as videos. The students elaborated freely based on their feelings towards the questionnaire. The video assignment was anticipated by the students as time-consuming and demanding, perhaps with a more neutral feeling about the assignments than anxious.

"I don't particularly like video submissions; making them nice and polished is usually more time-consuming and difficult than many other forms of submission." (Respondent 5)

Almost all found the assignments by video at the end more educational, challenging in a good way and even fun. Time is spent on work that differs from the usual, which should be considered and supported with clear guidance.

"Completing a video assignment is faster compared to writing, but preparing for the performance and arranging the space requires effort." (Respondent 7)

Casting, or agreeing on the roles in the teams, was one thing that drew attention to various tasks related to video delivery. All groups, except for one (out of eight), described group dynamics to be good. The groups worked well together, everyone participated and the assignment task and roles were divided evenly.

"Everyone was truly equal in terms of organizing the work, sharing responsibility, and doing the actual tasks." (Respondent 14)

The main tasks in group, or different roles that were mentioned were: Ideation/Concept development; Scriptwriting; Filming; Editing; Appearing on camera; Technical problem-solving. Also keeping team spirit high was mentioned, and this is of course a valuable team effort as well. It seems that in most cases (except for the one) the whole team was involved in every stage, thus enabling versatile learning experience for all team members whilst learning new ways of working either together or from one another.

"*In my group, the work was not divided very evenly; in the end, I found myself planning the videos and practically implementing the assignments myself, while my group mainly appeared in the videos." (Respondent 8)*

This is hardly an ideal situation, yet a possibility. The staff is advised to prepare appropriate measures for such occasions

The actual making of the videos was not seen as a problem. The smartphone was mostly used to make videos and then edited with various tools and on various platforms. Should either be more novel to any one member of a team, s/he quickly learned the required activity.

5. Conclusion

It seems that, despite all prior expectations, even fears the staff might have had, students are quite willing to engage in producing video submissions for their coursework. We had anticipated that they would be more hesitant about the technical implementation or about working with unfamiliar people, or video themselves in delivery process, but this proved not to be the case. Students approach the matter confidently in a very mature manner. Some even threw themselves at it and really used their imagination in scripting the videos, although this rather seems to be a positive exception. They generally participate well in working groups with people they do not know, and they are able to agree on working methods and, where appropriate, divide tasks according to strengths and interests in a notably mature way. It is worthwhile to encourage creativity when that is desired, since natural conservative caution is often students' first choice of approach. More broadly, clear instructions and criteria for both the work itself and its assessment must be in place from the outset.

One major obstacle might have been the actual phrasing of the assignment delivery. Some understood it perfectly but equally it was reported to be nigh incomprehensible. This underlines the significance of the clarity of the thing to be done, what is expected and what is being valued in the grading of the deliverable. Similarly, to be kept in mind is naturally the actual content-based assessment of the assignment, that they actually promote the case solution.

The collaborative learning process and the internalisation of course content appeared to be strengthened by the need to condense and present the material in a video format. In doing so, students actively transformed the knowledge they had acquired into a new form of expression, which supported both understanding and application.

As for the technical execution, students are ready to adopt new ways of working quite quickly, provided that they are encouraged appropriately and given guidance on how to proceed. The students' responses suggest that the university should provide adequate facilities for this kind of work if creative, original, and otherwise high-quality outcomes are expected. Even a suitably quiet space and location to make the video, seemed occasionally to be hard to find. What these facilities should be and how they can be implemented remains a matter for further consideration.

One learning objective was also to practice presenting one's acquired knowledge and learned contents. This was well achieved in groups that reported well-functioning cooperation, those teams who did not experience so well-functioning team structure did not realize the full potential. This may be addressed with better instructions on the activity, but not studied in depth in this paper.

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THE MEDIATING ROLE OF MISCONCEPTIONS IN BLENDED LEARNING'S IMPACT ON 3D TRIGONOMETRY ACHIEVEMENT: A STRUCTURAL EQUATION MODELLING STUDY

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Abstract

This study examines the mediating roles of conceptual understanding (CU) and misconceptions (ME) in the relationship between blended learning (BL) and academic achievement (ACH) in Grade 12 three-dimensional (3D) trigonometry. Grounded in social constructivism, an explanatory sequential mixed-methods design was employed, integrating structural equation modelling (SEM) with qualitative interviews and classroom observations. Data were drawn from 381 learner scripts and a focal sub-sample of 30 students and three teachers in South African public schools situated within the Chris Hani West District. Quantitative results confirm that BL positively predicts conceptual understanding ($\beta = 0.32$) and academic achievement ($\beta = 0.25$), while negatively predicting misconception ($\beta = -0.21$). Conceptual understanding reduces misconceptions ($\beta = -0.40$) and enhances academic achievement ($\beta = 0.35$), with misconceptions negatively impacting performance ($\beta = -0.28$). Bootstrapped mediation analysis identifies significant indirect effects of blended learning on academic achievement through conceptual understanding ($\beta = 0.11$) and misconceptions ($\beta = 0.06$), and via a serial pathway via conceptual understanding → misconceptions → academic achievement ($\beta = 0.10$). Conceptual errors accounted for 65.70% of learner scripts. Qualitative triangulation confirms that dynamic visualisations, dialogic tasks, and formative feedback are most effective in disrupting persistent error patterns. The study argues that blended learning, when strategically designed to target misconceptions, improves conceptual mastery and, by reducing errors, indirectly boosts achievement. Findings offer actionable instructional design principles for STEM education in resource-constrained settings.

Keywords: *Blended learning, misconceptions, 3D trigonometry, mathematics achievement, structural equation modelling.*

1. Introduction

Mathematics education in South Africa confronts deep-rooted systemic challenges, including chronic underresourcing, teacher capacity deficits, and gaps in curriculum implementation, that collectively depress learning outcomes across secondary schooling (Maqoqa & Saziwa, 2025; Muyambi & Ahiaku, 2025). These pressures are most acutely felt in spatially demanding topics, of which three-dimensional (3D) trigonometry is among the most cognitively taxing for Grade 12 learners. The topic demands simultaneous facility with spatial reasoning, diagram interpretation, and the application of trigonometric ratios across planes and solids, competencies that learners frequently lack (Hamzic & Takaci, 2017).

Blended learning, the systematic integration of digital instructional tools with face-to-face pedagogy, has attracted growing interest as a mechanism for addressing such conceptual difficulties (Baidoo & Luneta, 2024). Dynamic visualisation platforms such as GeoGebra offer spatial scaffolding that static textbook diagrams cannot provide, while asynchronous e-quizzes enable formative feedback at scale (Bayaga, 2024). Despite this potential, the field lacks rigorous empirical modelling of precisely how blended learning quality translates into achievement gains. Specifically, the mediating roles of conceptual understanding and misconceptions in this relationship remain undertheorised and underquantified.

This study addresses that gap by testing a theoretically grounded structural model in which BL influences ACH both directly and indirectly through CU and ME. Three hypotheses organise the inquiry: (H_1) BL positively predicts CU and ACH while negatively predicting ME; (H_2) CU reduces ME and enhances ACH; and (H_3) ME mediates the BL-ACH relationship. By integrating SEM with qualitative classroom data, the study contributes both statistical rigour and contextual depth to the blended learning literature.

2. Literature review

2.1. Blended learning in mathematics education

Blended learning offers a flexible instructional architecture that allows teachers to combine synchronous, face-to-face interaction with asynchronous digital engagement. In mathematics, this dual modality enables learners to revisit challenging concepts at their own pace while still benefiting from teacher-mediated dialogue (Bayaga, 2024). Juandi et al. (2025) demonstrate that blended delivery significantly improves secondary learners' conceptual understanding of mathematics compared to traditional instruction, particularly when digital tasks are aligned with specific conceptual goals rather than used as mere supplements. In the South African context, Baidoo and Luneta (2024) document the specific affordances of blended learning for 3D trigonometry, noting that GeoGebra-based lessons dramatically improve learners' ability to identify angle relationships in pyramids and prisms. This improvement is attributed not to technology per se, but to the quality of instructional design embedded within blended environments, a distinction that underscores the centrality of BL as a construct in the present study.

2.2. Misconceptions and error analysis in trigonometry

Misconceptions in mathematics are not random errors; they are systematic, often internally consistent cognitive structures that resist correction without targeted intervention (Baidoo & Luneta, 2024). In trigonometry, learners persistently conflate 2D and 3D angle properties, misapply trigonometric ratios to three-dimensional solids, and struggle to project spatial configurations onto two-dimensional representations (Juandi et al., 2025). Skemp's (1978) distinction between relational and instrumental understanding is instructive here: learners operating instrumentally may execute trigonometric procedures correctly in familiar contexts but collapse when spatial demands increase, precisely because their underlying conceptual schema is brittle. Error analysis, as a diagnostic methodology, offers a structured means of identifying and classifying misconception patterns in learner work (Baidoo & Luneta, 2024). Applied to 3D trigonometry scripts, it reveals that conceptual errors, rather than procedural calculation mistakes, are the dominant impediment to achievement, with direct implications for instructional targeting.

2.3. Constructivism as a theoretical framework

This study is grounded in Vygotsky's social constructivism (Vygotsky & Cole, 2018), which holds that conceptual development occurs through mediated, socially scaffolded interaction. Blended learning environments instantiate this framework by providing multiple, layered mediating tools: dynamic digital representations, peer discourse tasks, and formative feedback systems. Dahl and Mørch (2025) argue that constructivist mathematics pedagogy requires learners to actively confront cognitive conflict; blended environments, when well-designed, systematically engineer such conflict through peer comparison activities and immediate error notification. The present study positions BL as the instructional operationalisation of constructivist design quality.

3. Methodology

3.1. Research design

An explanatory sequential mixed-methods design (Haynes-Brown, 2025) was employed. In Phase 1, SEM was used to quantify and test hypothesised structural relationships. In Phase 2, qualitative data from semi-structured interviews and classroom observations were thematically analysed (Haynes-Brown, 2025) to contextualise and explain quantitative outcomes. This sequencing ensures that qualitative inquiry is driven by, and responsive to, specific patterns emerging from the structural model.

3.2. Participants and setting

Participants were Grade 12 mathematics learners (N = 381) drawn from six purposively selected public high schools in the Chris Hani West District, Eastern Cape, South Africa. Schools were selected to represent a range of resource levels while maintaining curriculum comparability. A focal sub-sample of 30 learners, stratified by achievement quartile, and three mathematics teachers participated in qualitative data collection. Prior term scores served as covariates to control for baseline differences.

3.3. Measures

Four latent constructs were operationalised. BL was assessed through 20 structured classroom observations, teacher instructional logs, and learner surveys ($\alpha = 0.86$), with indicators capturing visualisation tool use, digital task alignment, and feedback quality. CU was measured via a 15-item validated test assessing angle definitions, spatial reasoning, and diagram interpretation ($\alpha = 0.88$). ME was

operationalised through error-coded learner scripts using a four-category rubric (conceptual, transformation/representation, procedural, encoding), with high inter-rater reliability ($\kappa = 0.82$). ACH was measured by a standardised 3D trigonometry examination aligned with the South African CAPS curriculum ($\alpha = 0.90$).

3.4. Analytical strategy

Quantitative data were analysed in Mplus 8.3. Construct validity was evaluated through confirmatory factor analysis (CFA), with model fit assessed using CFI, TLI, RMSEA, and SRMR, and compared against established benchmarks (Henseler et al., 2025). Convergent validity was assessed using average variance extracted (AVE > 0.50) and composite reliability (CR). Discriminant validity was evaluated via the Fornell-Larcker criterion (Gaskin et al., 2025) and heterotrait-monotrait (HTMT) ratios (Henseler et al., 2025). Structural paths were estimated using maximum likelihood with bootstrapping (5,000 resamples) to test direct and indirect effects. Missing data, comprising less than 5% of the sample, were handled via full information maximum likelihood (FIML). Qualitative data were analysed thematically using deductive codes derived from the theoretical framework and inductive codes emerging from the data.

4. RESULTS

4.1. Error profile and descriptive statistics

Analysis of 381 learner scripts identified 4,072 coded errors across four categories. Table 1 presents the distribution. Conceptual errors dominated overwhelmingly at 65.70%, confirming that deficits in relational understanding, not procedural execution, are the primary driver of poor performance in 3D trigonometry. Transformation/representation errors constituted 18.23%, reflecting persistent difficulty in projecting three-dimensional spatial configurations onto two-dimensional diagrams. Procedural errors (10.84%) and encoding errors (5.23%) were substantially less prevalent.

Table 1. Distribution of error types in learner scripts (N = 381).

Error Type	Frequency (%)	Example Manifestation
Conceptual	65.70	Misapplication of trigonometric ratios in 3D solids
Transformation/Representation	18.23	Incorrect projection of 3D figures onto 2D planes
Procedural	10.84	Arithmetic errors in trigonometric calculations
Encoding	5.23	Misreading of angle labels in diagrams

Source: Author

Learners committing primarily conceptual errors scored significantly lower on achievement tests ($M = 42.31$, $SD = 11.24$) than those with predominantly procedural errors ($M = 55.67$, $SD = 9.87$), $t(379) = 8.92$, $p < .001$, $d = 1.23$. This large effect size ($d = 1.23$) underscores the functional severity of conceptual misunderstanding as a performance barrier. Cross-tabulation further revealed a significant negative correlation between CU scores and conceptual errors ($r = -0.45$, $p < .001$) and transformation errors ($r = -0.31$, $p < .001$), while the correlation with procedural errors was non-significant ($r = -0.09$, $p = .12$), suggesting that calculation mistakes operate through a distinct cognitive pathway.

4.2. Measurement model

The CFA confirmed excellent fit: χ^2 (248) = 512.36, $p < .001$; CFI = 0.95; TLI = 0.94; RMSEA = 0.06, 90% CI [0.05, 0.07]; SRMR = 0.05. All standardised factor loadings were significant ($p < .001$) and ranged from 0.61 to 0.85, indicating that each indicator contributed substantively to its latent construct. Cronbach's alpha values ranged from 0.84 to 0.90, and composite reliability from 0.78 to 0.88, exceeding established thresholds (Haynes-Brown, 2025). AVE values (0.52-0.64) exceeded the 0.50 benchmark, confirming convergent validity (Gaskin et al., 2025). The Fornell-Larcker criterion was satisfied, as the square roots of AVE (0.72 to 0.80) exceeded all inter-construct correlations (maximum r = 0.68), and HTMT ratios remained below 0.85, confirming discriminant validity (Henseler et al., 2015). Measurement invariance across gender groups was established at the scalar level ($\Delta CFI < 0.01$), permitting meaningful group comparisons (Gaskin et al., 2025).

4.3. Structural model and mediation

The structural model demonstrated acceptable fit: $\chi^2(312) = 642.18$, $p < .001$; CFI = 0.95; TLI = 0.94; RMSEA = 0.06, 90% CI [0.05, 0.07]; SRMR = 0.06. All hypothesised direct paths were statistically significant. BL positively predicted CU ($\beta = 0.32$, SE = 0.07, $p < .01$; H_1 supported) and ACH ($\beta = 0.25$, SE = 0.09, $p < .05$), and negatively predicted ME ($\beta = -0.21$, SE = 0.08, $p < .05$; H_1 supported). CU exerted a strong negative effect on ME ($\beta = -0.40$, SE = 0.06, $p < .001$; H_2 supported) and a positive effect on ACH ($\beta = 0.35$, SE = 0.08, $p < .001$). ME negatively predicted ACH ($\beta = -0.28$, SE = 0.07, $p < .01$).

Bootstrapped mediation analysis revealed three significant indirect pathways (H_3 supported). BL → CU → ACH yielded $\beta = 0.11$, 95% CI [0.05, 0.18], $p < .01$. BL → ME → ACH yielded $\beta = 0.06$, 95% CI [0.02, 0.12], $p < .05$. The serial mediation path, BL → CU → ME → ACH, yielded $\beta = 0.10$, 95% CI [0.04, 0.17], $p < .01$, accounting for 28.57% of BL's total effect on ACH. Across all pathways, 64.29% of BL's total effect on achievement operated through the two mediators, indicating that the dominant influence of blended learning on performance is cognitive and indirect rather than direct. The structural model accounted for substantial variance in CU ($R^2 = 0.28$), ME ($R^2 = 0.36$), and ACH ($R^2 = 0.45$), representing moderate to large effect sizes in educational research (Grissom & Kim, 2005). Multi-group analyses confirmed structural invariance across gender ($\Delta CFI < 0.01$), and the inclusion of prior mathematics achievement as a covariate did not substantively alter path coefficients, confirming robustness.

4.4. Qualitative triangulation

Three themes emerged from interview and observation data, each corresponding to a structural pathway. First, visual-spatial bridging: teachers reported that GeoGebra animations enabled learners to dynamically manipulate angle relationships that static diagrams obscured. One teacher noted that learners who had persistently failed to distinguish angles between lines and planes could suddenly do so after manipulating digital 3D models, a qualitative mechanism explaining the BL → CU pathway (Juandi et al., 2025). Second, cognitive conflict induction: learners reported that peer explanation tasks within digital whiteboard activities exposed contradictions in their reasoning. Articulating a solution to a peer frequently prompted self-correction, providing a classroom-level account of the CU → ME pathway (Baidoo & Luneta, 2024). Third, formative feedback immediacy: learners valued e-quiz feedback that identified and explained errors in real time rather than at the point of summative assessment (Bayaga, 2024). This mechanism directly explains the BL → ME pathway and the overall serial mediation chain.

5. Discussion

The study yields three principal findings, each with theoretical and practical significance. First, BL exerts meaningful effects on achievement primarily through cognitive mediators rather than directly, with 64.29% of its total effect operating indirectly. This undermines naïve assumptions that technology integration improves outcomes through simple exposure; it establishes instead that the quality of pedagogical design determines whether blended environments produce the conceptual restructuring necessary for achievement gains (Dahl & Morch, 2025). Second, the serial mediation path (BL → CU → ME → ACH) advances existing error analysis frameworks (Baidoo & Luneta, 2024) by quantifying how instructional quality translates into misconception reduction through the intermediate development of conceptual understanding. Third, the dominance of conceptual errors at 65.70% of all coded errors, coupled with a large between-group effect size ($d = 1.23$), confirms that practitioner focus on procedural drilling in 3D trigonometry is misallocated; relational understanding is the true performance bottleneck (Skemp, 1978).

The findings carry direct implications for instructional design. Dynamic visualisation tools such as GeoGebra should not be used as digital analogues of static diagrams but as interactive scaffolds that require learner manipulation, as this activates the spatial reasoning processes that underlie CU development (Hamzic & Takaci, 2017). Dialogic tasks, in which learners must articulate and defend solution strategies to peers, are particularly effective at inducing the cognitive conflict necessary for misconception correction (Baidoo &Luneta, 2024). Formative e-quizzes should provide explanation-rich, immediate feedback rather than merely signalling right or wrong, as the qualitative data confirm that feedback quality is a primary driver of error reduction (Juandi et al., 2025).

Several limitations constrain the scope of these conclusions. The study was conducted within a single district, restricting generalisability. The cross-sectional design prevents causal inference about the longitudinal persistence of misconception reduction. BL measurement, while psychometrically robust, relied partly on teacher self-reports, which may introduce social desirability bias. Learners with very low baseline spatial ability appeared to experience limited transfer from digital manipulative tasks to paper assessments, a moderating effect that the SEM model does not capture and that future research should explicitly test.

6. Conclusion

This study provides rigorous empirical evidence that blended learning quality improves achievement in 3D trigonometry primarily by developing conceptual understanding and reducing misconceptions, not through direct instructional transmission. The serial mediation pathway, BL → CU → ME → ACH, offers a parsimonious yet explanatorily rich model of how well-designed blended pedagogy operates cognitively. Practically, this means that investing in instructional design quality, specifically dynamic visualisation, dialogic tasks, and formative feedback, yields greater achievement returns than technology access alone. For policymakers in resource-constrained contexts, the study demonstrates that freely available tools such as GeoGebra, when deployed within a theoretically grounded blended architecture, can substantively disrupt persistent misconceptions that undermine STEM participation. Future research should pursue longitudinal designs, experimental manipulation of specific blended components, and investigation of spatial ability as a moderator of these effects.

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GENDER DISPARITIES IN STEM DEGREES: EVIDENCE FROM HIGHER EDUCATION AND LABOR MARKET

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Abstract

The growing demand for highly qualified professionals in science, technology, engineering, and mathematics (STEM) has intensified concerns about persistent gender inequalities along educational and professional pathways. Despite sustained policy efforts, significant gender gaps remain in STEM education, particularly in engineering and information and communication technologies (ICT), with direct implications for labour market outcomes and wage structures in the technology sector. Understanding the drivers of these disparities is essential for designing effective interventions. This study examines gender inequality across the STEM pipeline, linking higher education choices to labour market outcomes, with a specific focus on ICT-related fields. First, a descriptive analysis is conducted using secondary data to assess gender gaps in STEM degrees at the European level, with particular attention to Spain and the Universitat Politècnica de València (UPV). Results confirm a pronounced under-representation of women in STEM programmes, especially in ICT degrees, which cannot be explained by differences in academic performance. Second, to investigate the determinants of students' engagement with STEM studies, an original questionnaire was developed based on an extensive literature review. The survey captures key individual, social, and institutional factors, such as interest, self-efficacy, aspirations, stereotypes, parental support, and teacher encouragement, that may influence STEM educational decisions. The final sample consists of 151 undergraduate students from the Universitat Politècnica de València. Data are analysed using structural equation modelling techniques PLS-SEM, drawing on validated theoretical frameworks. The findings indicate that gender disparities in STEM education translate into unequal participation in the technology labour market, where women occupy approximately 28% of STEM-related jobs in Spain, and less than 20% of ICT positions. While a gradual reduction in the gender pay gap is observed, occupational segregation remains substantial. The multi-group analysis reveals notable gender-specific effects: parental and teacher support play a more decisive role for women in shaping STEM career aspirations, whereas beliefs about the STEM sector exert a stronger influence on women's interest levels compared to men. Contrary to expectations, some hypotheses, such as the direct impact of gender stereotypes on aspirations, are not significant. Overall, the results highlight the importance of early social support mechanisms and institutional interventions in addressing gender inequality in STEM education and ICT careers, contributing to evidence-based policy discussions aligned with SDG 4 and SDG 5.

Keywords: *STEM career, gender inequality, wage gap, higher education, structural equation modeling.*

1. Introduction

The rapid digital transformation of modern economies has significantly increased the demand for highly qualified professionals in science, technology, engineering, and mathematics (STEM). These disciplines are widely recognised as key drivers of innovation, productivity, and economic competitiveness (European Commission, 2025). However, despite the growing importance of STEM skills, persistent gender disparities remain along the educational and professional pathways associated with these fields. Women continue to be underrepresented in many STEM disciplines, particularly in engineering and information and communication technologies (ICT), which limits both individual career opportunities and the diversity of talent available to the labour market.

At the European level, women represent nearly half of tertiary education graduates but remain significantly underrepresented in STEM programmes. According to European Comision, women account for approximately 32% of STEM graduates in the European Union, with even lower participation rates in ICT fields. The gender imbalance is particularly pronounced in engineering and computer science programmes, where women often represent less than one quarter of enrolled students. These disparities extend beyond higher education and are reflected in labour market outcomes. In Spain, women represent only 17.5% of the employed population with STEM education, highlighting the persistent underrepresentation of women in these areas (ONTSI, 2025). Such imbalances have important implications for innovation capacity, economic growth, and the achievement of gender equality goals.

The persistence of gender gaps in STEM has generated extensive research aimed at identifying the factors that influence students' educational choices and career aspirations. Previous studies have shown that these disparities cannot be fully explained by differences in academic performance or cognitive ability (Ceci et al., 2014; Wang and Degol, 2017). Instead, a complex combination of psychological, social, and contextual factors appears to shape students' engagement with STEM disciplines. These factors include individual interests, perceptions of competence, social expectations, exposure to role models, and support from family and educational environments (Cheryan et al., 2017).

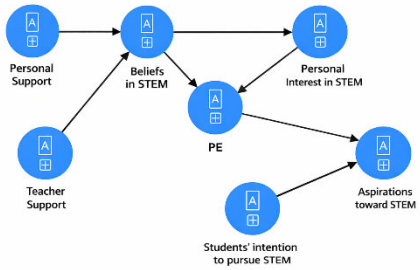
A widely used framework to explain career development processes is Social Cognitive Career Theory (SCCT) (Lent et al., 1994, Lent and Brown, 1996). SCCT posits that individuals' career interests, goals, and choices are shaped by the interaction of self-efficacy beliefs, outcome expectations, and personal goals within specific environmental contexts. Within the context of STEM education, students' confidence in their ability to successfully perform STEM tasks and their beliefs about the value and usefulness of STEM careers are key determinants of their interest and intention to pursue these fields. Furthermore, contextual influences such as parental encouragement, teacher support, and exposure to STEM activities can reinforce or weaken these beliefs. In addition to cognitive and motivational factors, gender stereotypes and social expectations may influence how students perceive STEM disciplines and their own capabilities within them. Stereotypical beliefs that associate technical competence or mathematical ability with men may discourage female students from considering STEM careers, particularly in male-dominated domains such as engineering and computer science (Cheryan et al., 2017). Within this context, understanding the determinants that shape students' interest and aspirations toward STEM careers is essential for designing effective educational and policy interventions aimed at reducing gender inequalities.

2. Conceptual analysis

2.1. Conceptual model

Based on SCCT (Lent et al., 1994, Lent and Brown, 1996), this study proposes a conceptual model to explain students' academic aspirations toward STEM degrees show in Figure 1.

Figure 1. Conceptual model of factors influencing students' STEM academic aspirations.



2.2. Research hypothesis

Based on Social Cognitive Career Theory (SCCT) and the literature review, the following hypotheses are proposed:

H1. Parental support positively influences students' beliefs about the value and importance of STEM studies.

H2. Teachers' support positively influences students' beliefs about the value and importance of STEM studies.

H3a. Students' beliefs about STEM positively influence their intention to pursue STEM studies.

H3b. Students' beliefs about STEM positively influence their perceived self-efficacy in STEM-related subjects.

H4. Students' intention to pursue STEM studies positively influences their perceived self-efficacy in STEM-related subjects.

H5. Gender stereotypes related to the STEM sector influence students' academic aspirations toward STEM degrees.

H6. Students' perceived self-efficacy in STEM-related subjects positively influences their academic aspirations toward STEM degrees.

3. Research method

3.1. Statistical analysis

This study followed a two-step analytical approach using Partial Least Squares Structural Equation Modelling (PLS-SEM). In the first stage, the measurement model was assessed to examine the relationships between latent constructs and their observed indicators, as well as to evaluate the reliability and validity of the measurement scales. Following the guidelines proposed by Hair et al. (2019), indicator reliability was assessed by analysing the outer loadings of the indicators, which should ideally exceed the recommended threshold of 0.70. Internal consistency reliability was evaluated using Cronbach's alpha (α) and Composite Reliability (CR), with acceptable values above 0.70. Convergent validity was assessed through the Average Variance Extracted (AVE), which should be greater than 0.50 (Fornell and Larcker, 1981). In addition, discriminant validity was examined using three complementary approaches: the Fornell–Larcker criterion, the analysis of cross-loadings, and the heterotrait–monotrait ratio (HTMT) of correlations, which should remain below the recommended threshold values of 0.85 or 0.90 (Henseler et al., 2015).

In the second stage, the structural model was evaluated in order to analyse the hypothesised relationships among the constructs. The significance and relevance of the structural relationships were assessed through bootstrapping procedures.

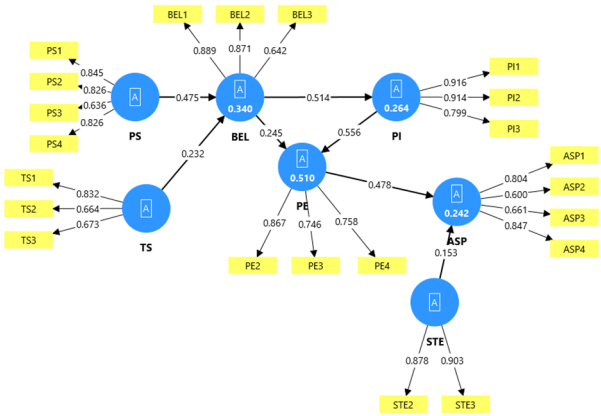
Finally, amulti-group analysis (MGA) was conducted to examine potential gender differences in structural relationships meanwhile the measurement invariance across gender was assessed using the MICOM procedure.

4. Results

4.1. Measurement model

4.1.1. Reliability and convergent validity. The measurement model was evaluated following the guidelines for Partial Least Squares Structural Equation Modelling (PLS-SEM) proposed by Hair et al. (2019). Since all constructs were specified as reflective composites (Type A), the assessment focused on examining the outer loadings of the indicators (Figure 2).

Figure 2. Outers loadings.



Indicator reliability was evaluated through the outer loadings, which should ideally exceed the recommended threshold of 0.70. Internal consistency reliability was assessed using Cronbach's alpha (α) and Composite Reliability (CR), with acceptable values above 0.70. Convergent validity was assessed through the Average Variance Extracted (AVE). Values greater than 0.50 indicate that the construct explains more than half of the variance of its indicators (Fornell and Larcker, 1981). The results confirm that all constructs meet these recommended thresholds.

4.1.2. Discriminant Validity. Discriminant validity was examined using two complementary approaches. First, the Fornell–Larcker criterion was applied by comparing the square root of the AVE of each construct with the correlations between constructs.In our case, the diagonal elements are greater than the correlations with other constructs, indicating adequate discriminant validity. Second, the heterotrait–monotrait ratio (HTMT) was analysed. All constructs obtain values of HTMT values below 0.90 indicate that constructs are empirically distinct (Henseler et al., 2015).

4.1.3. Significance of Indicator Loadings. The significance of the outer loadings was assessed using a bootstrapping procedure with 5,000 subsamples. Bootstrapping provides t-values and p-values to test the statistical significance of the loadings. The results indicate that all indicators are statistically significant ($p < 0.05$), confirming their contribution to the measurement of their respective constructs.

4.2. Structural model

The structural model was assessed following the procedures recommended by Hair et al. (2019). All hypothesis were supported (p-value <0.05).

The explanatory power of the model was assessed through the coefficient of determination (R^2). According to Hair et al. (2019), values of 0.25, 0.50, and 0.75 can be interpreted as weak, moderate, and substantial explanatory power, respectively. In addition, the effect size (f^2) was examined to determine the contribution of each exogenous construct to the endogenous constructs. Values of 0.02, 0.15, and 0.35 indicate small, medium, and large effects, respectively.

4.3. Multigroup analysis

A multi-group analysis (MGA) was conducted to examine potential gender differences in the structural relationships. Measurement invariance across gender was assessed using the MICOM procedure. The results of Compositional Invariance indicate that most constructs meet the invariance criteria, as the original correlations exceed the 5% quantile and permutation p-values are above 0.05. However, parental support (PS) does not achieve compositional invariance ($p = 0.001$), suggesting that the way this construct is formed differs between male and female students. Despite this exception, partial measurement invariance is established, which allows for meaningful multi-group comparisons of the structural relationships. The results indicate that most structural paths are statistically equivalent across male and female students. However, a significant difference emerges in the relationship between beliefs about STEM and the intention to pursue STEM studies.

5. Discussion

This study identifies beliefs about the STEM sector, parental support, and teachers' support as key factors shaping students' perceptions and motivations toward STEM careers. The results of the PLS-SEM model indicate that both parental and teachers' support significantly influence students' beliefs about STEM, highlighting the important role played by the social environment in shaping students' perceptions of STEM fields. These beliefs, in turn, strongly influence students' intention to pursue STEM studies, which subsequently contributes to the development of perceived self-efficacy in STEM-related subjects.

The results also show that perceived self-efficacy is the strongest predictor of academic aspirations in STEM, confirming the central role of confidence in one's own abilities when considering STEM educational pathways. In addition, gender stereotypes show a smaller but statistically significant effect on STEM aspirations, suggesting that although stereotypes may still influence students' perceptions, their impact is weaker compared with psychological factors such as beliefs, intentions, and self-efficacy.

From a theoretical perspective, these findings are consistent with Social Cognitive Career Theory (SCCT), which emphasizes the role of social context and cognitive factors in shaping career aspirations. The present study reinforces these findings by showing that support from parents and teachers contributes to strengthening positive beliefs about STEM, which in turn foster students' motivation and confidence in these fields.

From a practical perspective, these results suggest that initiatives aimed at strengthening students' beliefs and self-efficacy in STEM, together with increased support from parents and teachers, may contribute to fostering greater academic aspirations toward STEM careers.

Despite these contributions, the study presents several limitations. The sample is limited to university students, which may restrict the generalizability of the results. Future research could extend this model to secondary school students or early educational stages, where career aspirations are often formed, and could incorporate additional variables such as role models, institutional support, or exposure to STEM activities. Overall, the proposed model highlights the importance of beliefs, intentions, and perceived self-efficacy as central mechanisms explaining students' academic aspirations toward STEM careers, while also emphasizing the indirect but relevant role played by social support and gender stereotypes in shaping these aspirations.

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INCLUSIVE PRACTICES IN LARGE PRIMARY CLASSROOMS: TEACHER TRAINING AND RESEARCH IN SÃO TOMÉ AND PRÍNCIPE

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Abstract

Large class sizes remain a major challenge for the implementation of inclusive education, particularly in education systems facing structural constraints and limited resources. This paper presents an education and research project developed in São Tomé and Príncipe, aimed at supporting primary teachers working in large classrooms through inclusive and context-responsive pedagogical approaches. The project is grounded in an action–training–research framework and seeks to strengthen teachers' capacities to manage diversity, promote participation, and implement pedagogical differentiation in real classroom contexts. It is structured in interconnected phases: contextual diagnosis, teacher training workshops, collaborative reflection, and the progressive implementation and monitoring of inclusive practices. This paper focuses on the initial diagnostic phase, conducted over a short exploratory period, which aimed to identify key challenges, available resources, and prevailing conceptions of inclusive and special education. Data were collected through a semi-structured exploratory conversation with five purposively selected educational professionals, chosen for their direct experience in primary education and involvement in local school contexts. Data were analysed using qualitative content analysis following an inductive approach. Findings reveal persistent tensions between inclusive policy discourses and everyday classroom realities, particularly regarding class size, limited support structures, and constraints on pedagogical decision-making. At the same time, participants identified adaptive strategies and situated professional knowledge that can support more inclusive practices. These results are informing the design of context-sensitive training strategies and shaping subsequent phases of the project, including the development of collaborative professional learning spaces, classroom-based experimentation, and iterative monitoring processes. Based on the diagnostic findings, preliminary recommendations are proposed, emphasizing the need for practice-oriented training, peer collaboration, and the valorization of local pedagogical knowledge. This study highlights the role of teacher education and international cooperation in advancing inclusive education in complex and resource-constrained settings. The findings also contribute to a situated understanding of inclusive education in Portuguese-speaking African contexts, highlighting the relevance of contextually grounded professional development approaches.

Keywords: *Inclusive education, large classrooms, teacher training, action research, São Tomé and Príncipe.*

1. Introduction

Large class sizes remain a persistent challenge for the implementation of inclusive education, particularly in educational systems marked by structural constraints and limited resources. This issue is especially critical in primary education, where the consolidation of foundational learning and the early identification of developmental and learning difficulties are essential. High pupil density tends to limit individualised attention, constrain pedagogical differentiation, and reduce opportunities for active participation. However, international research consistently highlights that class size alone does not determine learning outcomes; rather, the quality of pedagogical practices plays a decisive role (UNESCO, 2015; Ainscow, 2020).

In Portuguese-speaking African countries such as São Tomé and Príncipe, this challenge assumes specific characteristics. The combination of demographic pressures, infrastructural limitations, and limited availability of specialised human resources contributes to classrooms with a high number of students and significant heterogeneity in learning profiles, rhythms, and needs. Within this context, teachers are frequently required to respond to diversity under conditions that are not always conducive to the systematic implementation of differentiated and inclusive practices.

Inclusive education provides a relevant framework for addressing these challenges. Rather than being restricted to specific groups of students, inclusive education is increasingly understood as a systemic and pedagogical approach focused on identifying and removing barriers to learning and participation, while recognising diversity as an inherent characteristic of educational contexts (Booth & Ainscow, 2011; Ainscow, 2020). In large classrooms, this perspective requires flexible pedagogical strategies, active methodologies, and forms of differentiation capable of engaging all learners (Florian, 2019; Tomlinson, 2014).

Within this framework, teacher professional development plays a central role. Sustained, collaborative, and context-sensitive training processes are particularly relevant in systems where specialised support is limited, as they enable teachers to reflect critically on their practices and develop strategies adapted to real classroom conditions. Furthermore, the literature highlights that inclusive education in resource-constrained contexts cannot rely exclusively on structural reforms or specialised resources. Instead, it requires pedagogical approaches that are flexible and context-responsive, enabling teachers to work with existing conditions while progressively transforming them.

This perspective is particularly relevant in large classroom settings, where diversity is intensified and where the teacher's capacity to organise learning environments, mediate interactions, and promote participation becomes central. Consequently, understanding teachers' perspectives and practices in such contexts is essential for designing meaningful and sustainable training interventions.

This paper analyses a training and research project developed in São Tomé and Príncipe, focusing on pedagogical practices in large primary classrooms. More specifically, it examines the project's initial diagnostic phase, aiming to identify challenges, resources, and perspectives among educational agents. The study seeks to contribute to the design of context-sensitive training strategies and to provide a situated understanding of inclusive practices in large classroom contexts, supporting future pedagogical interventions grounded in local realities.

2. Project framework and objectives

The study is part of a broader international cooperation project aimed at strengthening educational quality, equity, and inclusion in São Tomé and Príncipe through the articulation of teacher training, research, and pedagogical intervention. The project adopts an action research–training framework, integrating professional development, knowledge production, and contextualised educational action.

The intervention is structured in interconnected phases, including contextual diagnosis, teacher training workshops, collaborative reflection, implementation of participatory pedagogical methodologies, and progressive monitoring of practices. This approach reflects an understanding of teacher development as a continuous, situated, and practice-based process.

The present paper focuses exclusively on Phase I — Diagnosis, exploratory in nature. The main objective is to analyse how educational agents perceive inclusive education and pedagogical management in large classrooms, identifying key challenges, constraints, and potentialities. These findings are intended to inform the design of training strategies, support the development of collaborative professional learning environments, and guide subsequent phases of the project.

3. Methods

The study follows an action research–training approach, understood as a reflective, collaborative, and situated methodology that connects knowledge production, professional development, and pedagogical intervention (Miller & McGowan, 2018). This approach is particularly suited to complex educational contexts, as it allows for the analysis of practices and perspectives grounded in real professional experiences while simultaneously supporting change processes.

The present analysis focuses on data collected during the diagnostic phase, specifically through a semi-structured exploratory group conversation involving five purposively selected educational agents. Participants included primary school teachers, pedagogical supervisors, representatives of the Ministry of Education, and teacher educators, all with relevant experience in the Santomean educational system.

The purposive sampling strategy aimed to ensure diversity of perspectives while maintaining relevance to the research objectives. Participants were selected based on their direct involvement in primary education and their knowledge of classroom practices, supervision processes, and educational policy implementation.

The conversation, lasting approximately two hours, was guided by a structured script covering themes such as conceptions of inclusive education, classroom management, pedagogical strategies in large classes, organisation of space and time, student participation, collaboration among professionals, and training needs. The session was audio-recorded and fully transcribed.

Data analysis was conducted using qualitative content analysis (Bardin, 1977), following an inductive approach. The analytical process involved iterative reading of the corpus, identification of meaning units, initial coding, and the construction of emerging thematic categories. These categories were organised into analytical dimensions, including conceptions of inclusive education, pedagogical management of large classes, relational dynamics, working conditions, and structural constraints.

Participants were anonymised (P1–P5), ensuring confidentiality and adherence to ethical principles of educational research. In addition to the exploratory group conversation analysed in this paper, the broader diagnostic phase included complementary procedures, such as document analysis, informal meetings with local educational stakeholders, and preliminary classroom observations. Although not analysed in detail here, these sources supported the interpretation of the qualitative data and reinforced the identification of structural constraints, organisational challenges, and context-responsive pedagogical practices already mobilised by teachers.

4. Results and discussion

The findings reveal a complex and nuanced picture of inclusive education in large primary classrooms, marked by the coexistence of conceptual alignment with inclusive principles and significant contextual constraints.

4.1. Conceptions of inclusive education and perceived limits

Participants demonstrated a broad understanding of inclusive education, recognising it as a transversal responsibility embedded in everyday pedagogical practice rather than as a set of responses directed exclusively at students with specific educational needs. This perspective is consistent with contemporary theoretical frameworks. However, this understanding coexists with a clear awareness of practical limitations. As one participant stated, “when there are forty or fifty pupils, many end up going unnoticed” (P3). This highlights the tension between inclusive discourse and the conditions required for its effective implementation.

4.2. Large classes as a normalised structural condition

Large classes are perceived as a normalised feature of the educational system. Participants reported that classes with more than 40 pupils are common and considered part of everyday school reality. This normalisation shapes pedagogical expectations and limits the perceived feasibility of alternative organisational arrangements. At the same time, large classes were associated with challenges in maintaining attention, managing behaviour, and implementing differentiated or participatory activities. These difficulties are exacerbated by limited physical space and scarce pedagogical resources.

4.3. Adaptive pedagogical strategies

Despite these constraints, participants reported the use of adaptive strategies aimed at managing diversity and promoting participation. These include small-group work, cooperative learning, project-based approaches, and the use of locally available materials. Such strategies reflect context-responsive practices that emerge from teachers’ professional experience and their capacity to adapt to challenging conditions. Rather than applying predefined models, teachers develop situated responses that allow them to reorganise classroom dynamics and support student engagement.

4.4. Relational dimension and classroom management

The relational dimension of teaching emerged as a central element. Participants emphasised the importance of trust, proximity, and emotional connection in managing large classes. The pedagogical relationship was described as a key factor for promoting student engagement, regulating behaviour, and supporting participation. In this sense, relational practices function as a core pedagogical resource, particularly in contexts where structural constraints limit other forms of intervention.

4.5. Professional collaboration and training needs

Participants highlighted the importance of collaboration among teachers and the value of sharing practices and experiences. However, they also noted that such collaboration is not yet systematically supported by institutional structures. The need for continuous, practice-oriented training emerged as a key theme, particularly in relation to pedagogical differentiation, inclusive practices, and classroom management strategies adapted to large groups.

4.6. Implications for teacher training and pedagogical development

The findings of the diagnostic phase provide important implications for the design of teacher training processes in contexts characterised by large classes and limited resources.

First, they highlight the need for training models that are strongly anchored in practice, enabling teachers to reflect on their own classroom experiences and to experiment with strategies adapted to their specific contexts.

Second, the data suggests that training should prioritise pedagogical approaches that are feasible within existing constraints, such as cooperative learning, small-group organisation, and the use of locally available materials. Rather than promoting idealised models that may be difficult to implement, training should focus on strategies that can be realistically integrated into teachers' daily practice.

Third, the importance of the relational dimension indicates that teacher training should also address aspects related to classroom climate, communication, and the construction of positive pedagogical relationships. Additionally, the findings reinforce the relevance of collaborative professional learning. The creation of spaces for peer exchange, joint reflection, and shared problem-solving may contribute to strengthening teachers' professional agency and to sustaining changes in practice over time. Finally, the diagnostic phase confirms the importance of adopting a phased and iterative approach to intervention, providing a foundation for subsequent phases of the project.

4.7. Contextual constraints and pedagogical possibilities

The findings also highlight the importance of analysing inclusive education within its broader contextual conditions. Structural constraints, including limited infrastructure, high pupil–teacher ratios, and scarcity of specialised resources, play a significant role in shaping pedagogical practices. These conditions do not merely limit teachers' actions but actively configure the possibilities and boundaries of classroom intervention. However, the data suggests that these constraints do not entirely determine pedagogical practices. Instead, teachers demonstrate the capacity to reinterpret and negotiate these conditions, developing contextually situated strategies that allow them to respond to diversity. This reinforces the idea that inclusion should be understood not only as a policy goal but as a situated pedagogical process that emerges through everyday practice. In this sense, large classrooms can be seen simultaneously as a constraint and as a space of pedagogical possibility. While they present clear challenges in terms of individualised support and classroom management, they also create opportunities for collaborative learning, peer interaction, and shared responsibility for learning. This dual perspective is particularly relevant for the design of training interventions, which should not focus exclusively on reducing constraints but also on identifying and expanding the pedagogical possibilities that exist within these contexts.

Overall, the findings suggest that the challenges associated with large classes are not solely determined by class size but by the interaction between structural conditions, pedagogical practices, and professional agency. Inclusive education in such contexts depends on the capacity to mobilise flexible, context-sensitive strategies and to support teachers through collaborative and sustained professional development. The diagnostic findings are already informing subsequent phases of the project, including training programmes, collaborative professional learning spaces, and classroom-based experimentation.

This interpretation is consistent with research that emphasises the role of teacher agency in contexts of constraint, where educators actively construct situated responses to complex challenges rather than simply implementing externally defined models. At the same time, the findings point to the risk of these adaptive strategies remaining isolated or informal if they are not supported by structured professional development processes. The data also highlights the importance of considering inclusion as a relational and organisational process. Furthermore, the normalisation of large classes raises important questions regarding equity and educational quality, suggesting the need for a dual approach that combines pedagogical innovation with broader structural and policy-level considerations.

5. Conclusions

This study analysed the diagnostic phase of a training and research project focused on inclusive education in large primary classrooms in São Tomé and Príncipe. The findings reveal the coexistence of inclusive pedagogical orientations with significant contextual constraints, highlighting both the challenges and the adaptive strategies developed by educational agents.

The results underline the importance of pedagogical flexibility, relational dimensions of teaching, and collaborative professional development as key elements in promoting inclusion in resource-constrained contexts. They also demonstrate that teachers play an active role in constructing context-responsive practices, mobilising available resources and adapting pedagogical strategies to support student participation.

At the same time, the study highlights the need for structured and sustained professional development processes capable of supporting the consolidation and expansion of these practices. Training models that are practice-based, collaborative, and context-sensitive appear particularly relevant in this regard. From a broader perspective, the findings suggest that inclusive education in large classroom settings requires an integrated approach that combines pedagogical, organisational, and institutional dimensions.

Although exploratory in nature and based on a small purposive sample, the study provides relevant insights into inclusive practices in a Portuguese-speaking African context and contributes to the design of training and research initiatives grounded in local realities. Future research should extend this analysis by examining the implementation and impact of pedagogical strategies over time, particularly in relation to student participation, learning outcomes, and well-being.

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EXPLORING THE ROLE OF ARTIFICIAL INTELLIGENCE IN DESIGN-DRIVEN STARTUP EDUCATION

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Abstract

The growing availability of Artificial Intelligence (AI) tools is reshaping entrepreneurship education, particularly within design-driven approaches to startup creation. While AI is increasingly used to support entrepreneurial activities, there is still limited understanding of how it influences the different phases of the startup creation process in higher education contexts. This paper investigates the role of AI within a design-driven startup education course, where students develop entrepreneurial ideas from opportunity identification to business model definition. The course integrates design methodologies with entrepreneurial and managerial tools, supporting students in navigating uncertainty, feasibility, and strategic decision-making. A structured survey was administered to students to assess the extent of AI usage and its perceived usefulness across key phases of the startup process, including opportunity identification, need analysis, concept development, market exploration, and business model definition. The results show that AI is perceived as particularly useful in early and analytical phases, where it supports information gathering, synthesis, and the exploration of alternative solutions. In these stages, AI functions as a cognitive amplifier, helping students navigate uncertainty and structure complex inputs. However, its perceived usefulness decreases in more strategic and decision-intensive phases, where human judgment, critical thinking, and responsibility become central. These findings highlight a tension between the exploratory potential of AI and its tendency toward risk-averse reasoning. From an educational perspective, this suggests framing AI as a cognitive sparring partner that stimulates thinking without replacing decision-making. The study contributes to the design of startup education models that leverage AI while preserving the uncertainty and risk that are fundamental to innovation-driven entrepreneurship.

Keywords: *Artificial Intelligence, startup education, design education, design-driven entrepreneurship, human–AI collaboration.*

1. Introduction and theoretical background

The growing diffusion of Artificial Intelligence (AI) is significantly transforming educational practices across multiple domains, including entrepreneurship education. Recent advances in generative AI systems have expanded students' access to information, analytical capabilities, and ideation processes, enabling new forms of interaction with knowledge and problem-solving (Luckin et al., 2016; Holmes et al., 2019). In particular, AI tools are increasingly used by students to support research activities, synthesize complex information, generate ideas, and structure arguments, thereby reshaping how learning processes are enacted and experienced.

In the context of entrepreneurship education, these transformations are particularly relevant. The startup creation process is characterized by high levels of uncertainty, ambiguity, and iterative learning, requiring students to navigate incomplete information, interpret emerging signals, and make decisions without full validation (Ries, 2011; Blank, 2020). Within this domain, design-driven approaches have gained increasing relevance, as they provide methodologies to address complexity through exploration, iteration, and user-centered inquiry (Brown, 2008; Martin, 2009).

Design-driven startup education integrates principles from Design Thinking, Design Sprint, and Lean Startup methodologies, combining creative exploration with analytical validation (Garbuio et al., 2018; Kremel & Wetter-Edman, 2019). These approaches emphasize a set of key competencies that are considered fundamental in entrepreneurial learning. First, they support the ability to identify and frame opportunities, enabling students to move beyond predefined problem spaces and actively construct

meaningful areas of intervention. This involves not only recognizing potential market gaps, but also interpreting weak signals and reframing initial ideas into more structured entrepreneurial directions.

Second, they foster the capacity to interpret user needs and contextual dynamics, which is central to developing solutions that are both relevant and viable. Through user-centered methods, students learn to engage with stakeholders, uncover latent needs, and situate their ideas within broader socio-economic and market contexts. Third, these approaches promote iterative experimentation and prototyping as a way to navigate uncertainty. Rather than pursuing linear planning, students are encouraged to test assumptions, develop early-stage concepts, and refine their ideas through continuous feedback loops. This iterative logic allows them to progressively reduce uncertainty while maintaining openness to change.

Finally, they develop the capability to make strategic decisions under conditions of incomplete information. In entrepreneurial contexts, decisions often need to be taken without full validation, requiring students to balance analytical reasoning with intuition and to assume responsibility for the risks associated with their choices. Importantly, entrepreneurship education is not only about developing viable business models, but also about fostering an entrepreneurial mindset characterized by adaptability, resilience, and a willingness to take risks (Sarooghi et al., 2019). In this sense, risk-taking is not a side effect of entrepreneurship, but a core component of innovation processes (Eisenmann, 2021).

This characteristic introduces a critical tension when Artificial Intelligence tools are integrated into the learning process. AI systems are typically designed to generate outputs based on patterns, probabilities, and existing data, often favoring plausible, coherent, and incremental solutions. While this makes them highly effective in supporting analysis, synthesis, and early-stage exploration, it may also lead to a bias toward risk-averse reasoning, potentially limiting the exploration of more radical or unconventional entrepreneurial directions.

The increasing adoption of AI in educational settings is beginning to intersect with these dynamics. Emerging studies suggest that AI tools can enhance learning by supporting information processing, accelerating ideation, and providing immediate feedback to students (Holmes et al., 2019; Zawacki-Richter et al., 2019). In entrepreneurship education, preliminary evidence indicates that AI can be particularly useful in early phases of the entrepreneurial process, such as opportunity exploration, market analysis, and idea generation, where access to diverse information and rapid synthesis can support students in expanding their understanding of potential directions.

At the same time, recent discussions highlight potential limitations and risks associated with the use of AI in entrepreneurial contexts. Because AI systems generate outputs based on patterns and probabilities derived from existing data, they tend to produce solutions that are coherent and aligned with dominant logics. While this can be beneficial for structuring knowledge and supporting analysis, it may also lead to more conservative and incremental outcomes, potentially constraining the exploration of innovative and high-risk entrepreneurial opportunities.

Despite these emerging insights, there is still limited empirical understanding of how AI is actually used by students within entrepreneurship education, and how its perceived usefulness varies across different phases of the startup creation process. In particular, there is a lack of research that explicitly connects the use of AI with the specific cognitive and decision-making dynamics of design-driven startup education, where exploration, iteration, and risk-taking are central.

This paper addresses this gap by investigating the role and perceived usefulness of AI within a design-driven startup education course. By analyzing how students use AI across the different phases of the startup creation process, the study aims to contribute to the understanding of how AI can support entrepreneurial learning while preserving the critical role of human judgment, responsibility, and risk-taking in innovation-driven contexts.

2. Educational context and methodology

The study is based on a didactic experimentation conducted within a design-driven startup education course offered at the School of Design of Politecnico di Milano. The course is designed to bridge design methodologies and entrepreneurial thinking, providing students with a hybrid framework to develop innovative startup ideas.

The educational model builds upon previous research on the integration of design and entrepreneurship, which highlights the importance of combining creative exploration with business-oriented validation (Carella et al., 2025; Garbuio et al., 2018). The course structure reflects this integration by combining:

- Design Thinking for opportunity exploration and problem framing,
- Design Sprint for rapid ideation and prototyping,
- Lean Startup for testing assumptions and validating business models.

Students work in teams to develop an entrepreneurial idea, progressing through key phases of the startup creation process: opportunity identification, need analysis, concept development, market and competitor analysis, business model definition, and basic economic evaluation. The course also includes lectures, guest talks from entrepreneurs, and project-based activities, allowing students to connect theoretical knowledge with real-world applications.

Within this context, students were allowed to use AI tools autonomously during the development of their projects. This choice reflects a realistic learning environment in which AI is available but not prescribed, enabling the observation of natural usage patterns.

To investigate the role of AI, a structured survey was administered at the end of the course. The questionnaire explored how AI was used and perceived across the different phases of the startup creation process, asking students to evaluate both its usefulness and the relevance of human contribution in each phase.

The data were analyzed using descriptive statistics and qualitative interpretation, with the aim of identifying patterns in AI usage and understanding how its perceived value changes across the entrepreneurial process.

3. Results and discussion

The results highlight a differentiated and non-uniform role of AI across the phases of the startup creation process. Students reported a higher perceived usefulness of AI in early and analytical phases, such as opportunity identification, need analysis, and market and competitor exploration. In these stages, AI was primarily used to support information gathering, synthesis, and the generation of alternative perspectives.

For instance, in the opportunity identification phase, students reported using AI tools to explore emerging trends, identify potential market gaps, and generate initial ideas. Similarly, during market and competitor analysis, AI was used to quickly synthesize large amounts of information, compare positioning strategies, and identify patterns that would otherwise require significant time and effort. In these contexts, AI functioned as a cognitive amplifier, enabling faster access to structured knowledge and supporting divergent thinking.

These findings are consistent with existing research on AI in education, which highlights its potential to enhance information processing, ideation, and exploratory learning (Holmes et al., 2019; Zawacki-Richter et al., 2019). In particular, AI appears to be especially effective in supporting phases characterized by high cognitive load and the need to process multiple sources of information, allowing students to expand their exploration space and engage with a broader range of possibilities.

However, as the process moved toward more strategic and decision-intensive phases—such as opportunity selection, value proposition definition, and business model development—the perceived usefulness of AI decreased significantly. Students emphasized that, while AI could suggest possible configurations or provide structured outputs, it was less effective in supporting decisions that required prioritization, trade-offs, and commitment to a specific entrepreneurial direction.

For example, in the definition of the business model, AI could support the structuring of revenue streams or cost components, but students reported difficulties in using AI outputs to make final strategic choices. Similarly, in the selection of a target market or the prioritization of a value proposition, students highlighted the need to rely on their own judgment, intuition, and interpretation of contextual factors. These findings align with previous research suggesting that AI systems are less effective in supporting tasks that require contextual interpretation, judgment, and responsibility (Luckin et al., 2016).

This shift across phases reveals a critical tension between the exploratory potential of AI and its tendency toward risk-averse reasoning. AI systems are trained on existing data and patterns, which often leads them to generate solutions that are plausible, coherent, and aligned with dominant market logics. While this characteristic is valuable in analytical phases, it may limit the generation of more radical or unconventional ideas.

In entrepreneurial contexts, however, innovation often emerges from the ability to take risks and pursue directions that cannot be fully justified through available data (Martin, 2009; Eisenmann, 2021). Startups frequently succeed by challenging existing assumptions and exploring uncertain opportunities, rather than optimizing them within known frameworks. In this sense, the tendency of AI to favor incremental solutions may conflict with the fundamental dynamics of entrepreneurial innovation.

From an educational perspective, this raises important questions about the role of AI in shaping students' cognitive processes. If students rely excessively on AI-generated outputs, there is a risk that they may adopt more conservative and risk-averse approaches, potentially limiting their ability to engage in creative and entrepreneurial thinking. This concern echoes broader discussions in the literature about the impact of AI on higher-order cognitive skills, including critical thinking and decision-making (Holmes et al., 2019).

At the same time, the results suggest that AI does not replace human reasoning, but rather reshapes how it is exercised. Students appear to renegotiate the role of AI across different phases, using it as a support tool when dealing with complexity and uncertainty, but reverting to human judgment when faced with decisions that require commitment and responsibility. This dynamic reflects a hybrid form of cognition, in which human and artificial intelligence interact in complementary ways.

In this context, framing AI as a cognitive sparring partner provides a useful interpretative lens. Rather than acting as a decision-making authority, AI can be seen as a tool that challenges assumptions, generates alternatives, and stimulates reflection. This perspective aligns with recent studies that emphasize the role of AI as an augmentative rather than substitutive technology in education (Luckin et al., 2016), and highlights its potential to support learning processes without undermining human agency.

4. Conclusions and educational implications

This study contributes to the understanding of how AI influences design-driven startup education by providing empirical insights into its role across different phases of the entrepreneurial process. The findings highlight that AI is particularly effective in supporting exploratory and analytical activities, such as opportunity identification, market analysis, and idea generation, where it enhances students' ability to process information and explore alternative solutions. At the same time, the study shows that its perceived usefulness decreases in phases that require strategic decision-making, prioritization, and commitment to a specific entrepreneurial direction, where human judgment, critical thinking, and responsibility remain central.

From an educational perspective, these results suggest that the integration of AI in entrepreneurship education should be carefully designed. Rather than focusing solely on how to use AI tools, educators should explicitly address when and how AI should be used across the different phases of the startup creation process. This implies recognizing that AI does not play a uniform role throughout the process, but rather supports different types of cognitive activities depending on the phase.

In particular, the findings point toward a phase-based approach to AI integration. AI can be effectively leveraged in early stages of the entrepreneurial process, where exploration, analysis, and synthesis are required, helping students expand their understanding of opportunities and structure complex information. However, its use should be more critically framed in later stages, where decisions involve prioritization, trade-offs, and risk-taking. In these moments, over-reliance on AI may lead to more conservative and incremental solutions, potentially limiting the development of innovative entrepreneurial directions.

A second key implication concerns the development of critical AI literacy. Students should not only learn how to use AI tools, but also how to evaluate their outputs, recognize their limitations, and understand the biases embedded in data-driven systems. This is particularly relevant in entrepreneurial contexts, where decisions often require moving beyond what is already known and embracing uncertainty. Developing the ability to critically engage with AI outputs becomes therefore a fundamental competence for future entrepreneurs.

A third implication relates to the design of reflective learning environments. The integration of AI should be accompanied by pedagogical strategies that encourage students to reflect on how AI influences their thinking and decision-making processes. This may include structured moments of reflection in which students assess when AI was helpful, when it was limiting, and how it affected their approach to risk and uncertainty. Such practices can foster metacognitive awareness and support students in developing a more conscious and intentional use of AI.

Within this perspective, positioning AI as a cognitive sparring partner represents a particularly valuable pedagogical approach. Rather than acting as a decision-making authority, AI can be used to challenge assumptions, generate alternatives, and stimulate reflection, while leaving responsibility for strategic choices to the student. This framing allows educators to leverage the strengths of AI in supporting exploration and analysis, without undermining the central role of human agency in decision-making.

Overall, the study suggests that AI should not be introduced as a tool to optimize or simplify the startup creation process, but rather as a resource to support learning while preserving the uncertainty and risk that are fundamental to innovation-driven entrepreneurship. By explicitly scaffolding its use and fostering critical engagement, educators can design learning experiences that integrate AI without compromising the development of entrepreneurial thinking.

Future research could further explore how different instructional strategies, levels of AI integration, and pedagogical approaches influence students' ability to balance AI support with human judgment. In particular, longitudinal studies could provide insights into how the use of AI affects the development of entrepreneurial competencies, including creativity, decision-making, and risk-taking, over time.

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INSTRUCTIONAL DESIGN IN PRACTICE: CONTRIBUTIONS TO THE STRUCTURING OF ONLINE COURSES FOR WOMEN ENTREPRENEURS

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Abstract

The growth of female entrepreneurship in the context of online education has driven the creation of digital courses as a strategy for sharing knowledge and generating income. However, many female entrepreneurs face difficulties in pedagogical organization, content structuring, and defining effective teaching-learning strategies. In this context, Instructional Design (ID) emerges as a methodology capable of supporting the systematic and pedagogical design of online courses. The present study aims to analyze how the application of Instructional Design contributes to the organization, content development, and definition of teaching-learning strategies in the creation of online courses by women entrepreneurs. Methodologically, the study adopts a quantitative approach, using questionnaires before and after specific training in Instructional Design, aimed at women entrepreneurs with previous experience in digital content production. The results show that the use of Instructional Design principles promotes greater clarity in the definition of objectives, better sequencing of content, and more appropriate choices of pedagogical strategies and technological resources. It is concluded that Instructional Design is a relevant tool for improving the quality of online training developed by women entrepreneurs, contributing to pedagogical effectiveness, the sustainability of courses, and the promotion of female entrepreneurship in the digital context.

Keywords: *Instructional design, online courses, women's entrepreneurship, digital education, teaching-learning strategies.*

1. Introduction

The contemporary educational landscape has been profoundly transformed by globalization and digitalization, driving demand for new learning modalities and greater flexibility (Nkoa & Song, 2023). This phenomenon has also fostered the growth of digital entrepreneurship, particularly among women, who view the digital education market as an opportunity for financial independence (IBQP, 2018).

In this context, women's entrepreneurship involves not only creating and managing one's own businesses, but also overcoming social and cultural barriers, as well as affirming gender equality within the entrepreneurial ecosystem.

However, several studies have shown that this trajectory is marked by structural challenges. Santos et al. (2023) emphasize that numerous obstacles to developing educational businesses in the digital environment—especially in online formats—persist due to inadequate pedagogical and technological guidance. These constraints add to the well-documented difficulties faced by women entrepreneurs, including balancing personal and professional responsibilities, limited access to credit and support networks, and limited training opportunities. Thus, it becomes evident that women's digital entrepreneurship should be understood as a complex process influenced by multiple factors, which calls for methodological strategies that support both pedagogical organization and the informed use of educational technologies.

Although many women have strong technical expertise in their fields, they often face the challenge of transferring offline knowledge into structured digital learning experiences. However, the lack of a solid pedagogical foundation often leads to the improvised use of formats and tools not designed for educational purposes, affecting the coherence of learning pathways and learning outcomes.

The literature (Azevedo et al., 2024; Filatro, 2020; Filatro & Piconez, 2004), indicates that creating effective courses requires more than content expertise; it requires a pedagogical foundation that supports the development of meaningful learning. This calls for reflection, discussion, and, above all, relevant considerations for addressing and examining the topic.

Within this framework, Instructional Design (ID) emerges as an approach that guides women entrepreneurs in systematically designing courses by aligning objectives, content, strategies, and resources. As Filatro (2008) argues, ID constitutes a body of knowledge oriented toward the planning and theorization of instructional strategies. Rodrigues et al. (2024) further emphasize that what truly makes this approach a powerful tool is its capacity to empower, plan, and structure courses and training programs that meet learners' needs, while remaining attentive to the specific demands of each woman entrepreneur. Based on this perspective, the following research question was defined: How does ID influence the creation of online courses developed by women entrepreneurs?

The general objective was to analyze the impact of applying ID methodologies on the autonomy and quality of online course production by women entrepreneurs.

The specific objectives were to: (i) identify the main technological and pedagogical barriers faced by digital entrepreneurs; (ii) assess the level of digital literacy and mastery of educational tools before and after exposure to ID; (iii) evaluate the effectiveness of transitioning from communication tools (WhatsApp/Telegram) to structured Virtual Learning Environments (VLEs); and (iv) explore participants' perceptions of the use of multimodal resources to support student engagement.

The paper is organized as follows: the next section presents the methodology, describing the study design, the sample, the data collection instruments, and the analysis procedures. Section 3 reports the main results, focusing on the technological and pedagogical barriers identified and the changes observed after the Instructional Design training. Finally, Section 4 presents the conclusions, discussing the implications for women's digital entrepreneurship, the study's limitations, and recommendations for future research.

2. Methodology

This research adopts a quantitative approach. This methodological choice is grounded in the need to objectively measure data, enabling the identification of patterns and trends through quantifiable responses. In addition, the purpose of this approach is to quantify how ID influences the creation of online courses, focusing on the strategies entrepreneurs use to organize and structure content.

The study aims to understand the practical effects of using ID in these women's day-to-day work. Data collection was conducted through two questionnaire-based surveys with closed-ended questions: Questionnaire 1 (pre-training), administered to assess participants' prior knowledge of the topic; and Questionnaire 2 (post-training), administered after specific ID training to understand how learning influenced participants' capacity to develop courses.

Data was organized and processed in Microsoft Excel. The analysis was based on percentages, frequencies, and means, and the results were presented visually in charts and tables to facilitate objective interpretation.

The sample included 15 women recruited through social media, with more than one year of experience creating digital content and at least 1,000 followers, but with no prior success with their online courses. The analysis focused on identifying motivations and difficulties. Strict ethical criteria were ensured, including anonymity, privacy, and informed consent, promoting transparency and trust throughout the research process.

3. Results

In the context of women's digital entrepreneurship, the transition from tacit knowledge to the provision of online courses is often marked by barriers that go beyond pedagogical organization. One of the most prominent obstacles is a lack of knowledge and technological insecurity.

While digital entrepreneurship offers opportunities for flexibility and income generation, limited mastery of specific tools remains a major constraint. The data indicate that approximately 38% of women entrepreneurs identify technical/technological knowledge as the main obstacle to organizing, planning, and implementing their courses.

Another relevant aspect is that many women attract students through social networks and become highly skilled in producing content for these platforms. However, there is a clear distinction between being a content creator and being a digital educator. Despite having experience creating free content for social media—especially Instagram—many study participants reported feeling blocked by the technical infrastructure required to develop an online course.

Entrenched gender stereotypes and social expectations that may affect entrepreneurs' self-esteem were also considered; these factors can generate insecurity about their ability to succeed in the digital world.

The lack of training in integrating technology with pedagogy meant that 75% of the entrepreneurs initially interviewed had not yet started creating their courses due to a lack of guidance. This indicates that ID functions not only as a method for organizing content but also as a solid foundation for addressing technological and planning pedagogical challenges.

The method helps identify which resources are truly necessary, preventing entrepreneurs from feeling overwhelmed by unnecessary tools. Because it is a process with multiple purposes, it allows for rapid adaptation and can be implemented at low cost. ID thus becomes an effective solution for women who face challenges in using technology.

The impact of ID training on women's technological perceptions is notable. The study shows that after exposure to the methodology, participants' views of digital tools changed significantly.

Overcoming technological barriers in women's entrepreneurship does not occur solely through the use of digital tools, but also through understanding the rationale behind their use in shaping the educational journey. ID plays a transformative role because understanding its processes gives the entrepreneur a clear view of how to apply technology in practice.

It is common for digital entrepreneurs to start delivering content via instant messaging apps like WhatsApp and Telegram. These tools are chosen for their ease of use and low initial cost, enabling rapid communication. Although they are more popular and seem easier, they hinder logical content organization and do not provide an environment conducive to the pedagogical depth required for meaningful learning. The study shows that before ID training, about 50% of participants had limited knowledge, mastering only these communication tools.

Unlike messaging applications, the VLE is the space where organized interaction and learning activities effectively take place. Migrating to a structured VLE provides features that communication tools lack, such as centralized multimodal materials and support for clear learning pathways.

The research data reveals a qualitative leap: after ID training, 75% of participants reported fully understanding VLE functionalities, demonstrating greater confidence in using these technologies and enabling diagnostic, formative, and summative assessments. The greatest gain from moving to a VLE platform is the ability to implement a robust assessment process. Before ID, entrepreneurs struggled to align assessments with learning objectives.

This alignment enables measuring student progress, identifying difficulties, and adjusting pathways in real time. After the training, 75% of participants reported learning to plan assessments that accurately reflect course objectives. This change is not merely technical; it is a fundamental step for business sustainability, contributing to training with a logical sequence, pedagogical clarity, and high added value. By mastering these tools autonomously, women entrepreneurs strengthen their authority and ensure that their students' learning is effective and transformative.

Finally, the results reinforce that the effectiveness of an online course does not depend on sophisticated media production, but rather on the quality of pedagogical interaction. ID supports the process as a facilitator that enables contextualized knowledge transfer, maintaining the priority of establishing a clear dialogue between educator and learner, thereby fostering an environment of trust and support.

Frequent interaction through these channels enables rapid feedback, which is essential to sustaining learners' motivation and attention throughout the process. One of the most widely used ID models, the Successive Approximation Model (SAM), offers strategies and tools that facilitate the exchange of ideas, opinions, and experiences (Castelhano, 2022).

4. Conclusions

This study concludes that applying Instructional Design (ID) significantly improves the quality of online courses developed by women entrepreneurs. The use of structured methodologies contributed to clarifying pedagogical objectives, sequencing content, and making more appropriate choices of teaching strategies and technological resources. It was also found that ID supports autonomy in building coherent learning pathways, promotes greater confidence in the use of educational technologies, and facilitates the transition from communication tools to Virtual Learning Environments.

In addition, ID proved essential for strengthening entrepreneurs' authority in the digital market by providing solid pedagogical foundations that enhance the effectiveness of training and add value to students' experiences. The study shows that the success of an online course does not depend exclusively on sophisticated resources, but on building consistent pedagogical interactions aligned with structured feedback processes and establishing a clear dialogue between educator and learner.

Given the identified limitations—particularly participants' difficulties in reconciling schedules, the dropout of some participants throughout the process, geographic distance that hindered interaction, and limited diversity of perspectives—future research should increase the number of participants and improve interaction mechanisms to strengthen representativeness, engagement, and data reliability. In addition, incorporating qualitative interviews may deepen understanding of the impacts of training, the challenges faced, and entrepreneurs' motivations in developing online courses.

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DECLARATIVE AND POETIC SYMBOLS IN ART STUDENTS' EXPLORATION OF ENVIRONMENTAL RENEWAL THROUGH LANTHIMOS'S BUGONIA

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Abstract

This paper presents a visual arts project in higher education that engages students' environmental concerns through film-based learning and creative practice. Four published posters from Yorgos Lanthimos's *Bugonia*, designed by Vasilis Marmatakis, functioned as a shared point of departure for examining how ecological crisis can be rendered intelligible through symbolic work, reframing and digital transformation. The enquiry considers what these images communicate with relative directness, while also asking what meanings emerge when publicity material is detached from narrative sequence and encountered as autonomous visual artefacts. The workshop draws conceptually on Bugonia, as described in Virgil's *Georgics* and Pliny's *Natural History*, where bees are said to arise from the carcass of an ox. This image of life emerging from decay is employed as an interpretive lens through which students consider renewal without recourse to idealised notions of repair. Read alongside the film's black-comic premise, the title's classical allusion also brings collective labour, ecological fear and sacrificial logic into view. Within this framework, bees and wings remain legible as signs of pollination, labour and ecological interdependence, while bodily exposure and planetary form register damage, contamination and vulnerability. Students were asked to distinguish between declarative symbols—stable, recognisable and socially legible—and poetic symbols, which operate more indirectly, affectively and with greater openness to subjective interpretation. Working in four groups, students progressed through close observation, discussion, digital intervention and reflective comparison. Their processes included inversion, equalisation, solarisation, layering and compositing, employed to test how visual meaning shifts when familiar signs are displaced without being erased. The transformed posters subsequently became the primary visual material for thematic analysis. Across the outcomes, stable symbols of exposure, planetary fragility and insect life did not disappear; rather, they were reconfigured into denser ecological images in which vulnerability, interdependence and instability became more perceptible. The paper argues that the movement from declarative to poetic symbolism offered students a practical means of reimagining ecological renewal as visually constructed, unstable and more-than-human.

Keywords: *Climate change education, project based learning, visual literacy, poster analysis, Bugonia.*

1. Introduction

Students often enter visual culture classrooms with a high degree of fluency in recognition, yet demonstrate less ease in engaging with uncertainty; this tension informs the interpretive orientation of the present study. Rather than treating images as stable carriers of meaning, the workshop approached the Bugonia posters as sites in which interpretation unfolds through engagement, transformation and re-reading. This position aligns with social semiotic perspectives, where visual meaning is understood as structured yet open to reconfiguration through context and use, as argued by Kress and van Leeuwen (2020), as well as with visual methodologies that foreground reflexive interpretation as a situated practice, as discussed by Rose (2023). As a filmic point of departure, Bugonia is especially generative because its official framing as a dark comedy centred on two conspiracy-obsessed men who kidnap the chief executive of a major company, convinced that she is an alien intent on destroying Earth, already places ecological fear, corporate power and unstable belief into tense relation (Focus Features, 2025). Within Lanthimos's black-comic register, this premise makes symbolic instability especially productive: what presents itself to the abductors as a sacred mission of planetary rescue stages conspiratorial thinking as a contemporary form of nemesis through which those tensions are violently refracted. It also places the threatened body under a sacrificial pressure that brings it close to what Agamben (2017) terms bare life. Within this framework,

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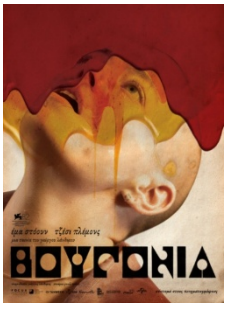
digital manipulation is not conceived as a secondary operation but as integral to the interpretive process itself. As Skains (2024) suggests, practice-based approaches enable knowledge to emerge through iterative making, while thematic analysis, following Braun and Clarke (2021), allows patterns of meaning to develop through sustained engagement rather than extraction. In this sense, uncertainty does not signal interpretive failure; rather, it sustains critical attention and reinforces the understanding that meaning remains contingent and relational. Against this background, the study is guided by two questions: how do students identify and differentiate declarative and poetic symbols within the *Bugonia* posters, and how do digital manipulation reorganise those symbols into new ecological meanings?

2. Theoretical framework

The interpretive dimension of digital image practices may be reconsidered beyond linear narratives of technological progress through a framework that foregrounds the stratified nature of media time. Rather than treating digital images as exclusively contemporary artefacts, such a perspective situates them within layered historical and material conditions, wherein past media forms, residual visual logics and technical affordances continue to shape present modes of seeing and meaning-making. As Jussi Parikka (2012) argues, media are embedded in material and cultural strata that exceed their immediate function, while Wolfgang Ernst (2013) foregrounds the operational temporality of media systems, emphasising the ways in which technological processes structure perception. From this perspective, digital transformations of images are not merely aesthetic manipulations but constitute interventions into the temporal and material conditions of visuality (Dvořák & Parikka, 2021). Here, media archaeology frames an approach attentive to how images retain earlier regimes while generating new ecological meanings. This is especially pertinent to Lanthimos's visual world, where bodily exposure and gesture have been read as sites of biopolitical pressure (Comanducci, 2024), and to the Greek Weird Wave more broadly, whose stylised forms have likewise been understood through tensions between regulation, embodiment and social order (Papanikolaou, 2021). The distinction between declarative and poetic symbols proves particularly productive, enabling a nuanced account of how visual signs operate across varying degrees of stability and openness. Declarative symbols tend to stabilise meaning through recognisable forms, whereas poetic symbols introduce forms of indeterminacy that resonate with the layered temporality central to media archaeological thought.

The emphasis on transformation as a mode of enquiry aligns with practice-based research, wherein making constitutes a form of knowledge production. Skains (2024) highlights that creative processes generate insights not fully accessible through discursive analysis alone, thereby reinforcing media archaeology's concern with the material and procedural dimensions of media. Digital interventions, therefore, do not simply alter visual surfaces but engage underlying conditions of possibility, revealing how meaning emerges through processes of layering, repetition and variation. At the same time, the ecological dimension of this approach is sharpened by Krenak (2023), who challenges anthropocentric assumptions regarding the value of nature. This position also resonates with recent work in environmental visual culture (Demos, 2023). Read alongside environmental humanities scholarship that foregrounds relational and plural understandings of value, this perspective shifts interpretation away from representation towards interdependence. As Buitendijk et al. (2024) argue, ecological meaning emerges through relational networks rather than discrete entities, a position reflected in the unstable and layered qualities of digitally transformed images. Consequently, an interpretive approach grounded in media archaeology enables a reconsideration of digital image practices as both historically situated and environmentally responsive. By tracing how visual forms persist, mutate and recombine across media contexts, this framework foregrounds the temporal continuities shaping contemporary image-making, framing uncertainty not as a lack of meaning but as a condition through which new ecological relations become perceptible.

Figure 1. Bugonia film posters designed by Vasilis Marmatakis.



Poster 1

Poster 3

Poster 4

Poster 5

3. Methodology and teaching scenario

The workshop was conducted with twenty postgraduate students, organised into four groups within a higher education, studio-based context. At Ionian University, the project was positioned within the wider pedagogical framework of the Joint Postgraduate Programme 'New Technologies in Environmental Education and Sustainable Development' (NTEES), jointly offered by the Department of Environment and the Department of Audio and Visual Arts, and in relation to the elective spring-semester 2025–2026 course *Environmental Aesthetics and Education*. Students began with close observation and careful description of the posters, approached as designed visual constructions rather than neutral publicity material. Marmatakis's portfolio situates *Bugonia* within an ongoing series of collaborations with Lanthimos, making the continuity of graphic authorship visible (Marmatakis, n.d.). This emphasis on contemporary Greek cinema as a resource for visual pedagogy also resonates with Panagopoulos and Papadopoulou's (2019) discussion of Weird Wave aesthetics in relation to teaching technologies in art education. A structured discussion followed, distinguishing between declarative symbols and those of a more open, poetically inflected character. Students then undertook a series of targeted digital interventions, including inversion, equalisation, solarisation, layering and compositing. These processes were framed not as technical exercises but as a means of testing how visual meaning might shift through transformation. The resulting images were treated as the primary visual material of the study and were accompanied by brief discussion notes that clarified the direction of interpretation. Analysis was conducted using a thematic approach, drawing on Braun and Clarke (2021), with particular attention to recurring patterns in the ways meaning was reorganised across the outputs. The transformed images and accompanying notes were considered together, allowing visual and verbal articulations to inform one another. Rather than remaining descriptive, the analysis unfolded through iterative engagement with the material, where shifts in colour, texture and composition—such as the displacement of natural flesh tones into more artificial or chemically inflected palettes—were grouped into broader patterns of meaning. These patterns coalesced into three interrelated themes: ecological vulnerability, posthuman hybridity, and an atmosphere of menace. This clustering did not fix interpretation but demonstrated how digital interventions unsettled more direct, declarative readings, opening towards forms of symbolic ambiguity in which ecological meaning appeared unstable, relational and affectively charged. Emphasis was placed on moments where descriptive clarity gave way to more open-ended interpretation, allowing uncertainty to function as a productive condition of analysis, in line with Hellman and Karlsson Häikiö (2024). In this way, the process traced not only the persistence of recognisable symbols, but also the ways in which meaning remained contingent and relational.

4. Case studies / analysis of transformations

The first transformation (Poster 5 in Figure 2) retains the face, liquid and exposed head of Poster 1 but overturns their chromatic logic. Inversion and equalisation turn flesh into blue-green topography and the dripping layer into a heated, unstable field. Declaratively, contamination and vulnerability remain. Poetically, however, the substance becomes harder to name: less honey, less blood, more climate, fever, chemical weather. Seen in light of Marmatakis's account of the Bugonia poster series as offering differentiated visual routes into the film's narrative rather than merely illustrating it (Bertoli, 2025), the intervention shifts the image from a relatively stable sign of bodily exposure towards a more diffuse sense of ecological atmosphere, as if skin and environment were no longer separable.

Figure 2. Digital transformations of the Bugonia posters produced by students.

Poster 5 *Poster 6* *Poster 7* *Poster 8*

In the second transformation (Poster 6 in Figure 2), the planetary sphere darkens and the wings acquire a spectral, electrically edged quality. The globe continues to read as world, the wings evoke insect life or hive logic, and the curled body signifies fragility. Yet chromatic inversion reconfigures the scene, rendering it less emblematic and more akin to an unstable habitat (Shobeiri & Westgeest, 2024). Against Bugonia's entanglement of bees, corporate power and planetary threat, such instability also recalls the abductors' sacrificial fantasy that one body might be offered up for the survival of the whole. The poetic symbol here does not introduce a new object, but rather establishes a new relational condition: the world becomes simultaneously enclosure, stage and threatened system. The third transformation (Poster 7 in Figure 2), intensifies the fragmentary logic of Poster 3. Wing veins traverse the head with increased visual force, and the face becomes a luminous terrain rather than a coherent portrait. At a declarative level, the image continues to present shaved-headed exposure, hybridisation and damage. Poetically, however, layering now suggests fractured perception and posthuman reconfiguration, a slippage consistent with readings of Lanthimos's cinema in which formal rigour and estrangement unsettle stable interpretation (Falvey, 2022). The human subject is not merely overlaid with insect form; it is rendered porous through it. It is at this point that the movement from declarative to poetic symbolism becomes most pronounced: the sign remains visible, yet its meaning loosens, expands and deepens. The fourth transformation (Poster 8 in Figure 2) extends the horizontal logic of Poster 4 into a darker, grainier field of suspension. Declaratively, the planetary sphere remains legible as world, while the flanking bodies register capture, distance and a strained relation between human scale and cosmic space. Poetically, however, the image holds the figure in a suspended state of exposure, as though vulnerability were drifting at the threshold between orbit, abduction and aftermath. The composition becomes less a resolved scene than an interval in which ecological threat is felt through estranged proximity rather than narrative closure.

5. Findings and discussion

Three findings recur across the workshop. First, the interventions clarified their own necessity by exposing latent symbolic tensions that close reading alone only partially disclosed. Second, declarative symbols proved durable without remaining fixed. Wings, planetary spheres, bodily exposure and contamination persisted through manipulation, yet no longer operated as singular meanings. Third, poetic symbolism emerged most forcefully when descriptive certainty weakened. Under such conditions, images invited ecological interpretation without collapsing into slogan. This was particularly important given Lanthimos's black-comic treatment of obsessive online conspiracism, which keeps the posters poised between declarative statement and poetic excess rather than allowing meaning to settle into a single message. This carries clear pedagogical significance. Rather than merely decorating posters, students used transformation as a means of thinking with images, a process that cultivates symbolic awareness, visual discrimination and ecological sensitivity in ways that align with recent work in arts-based environmental pedagogy by Farrar et al. (2024) and Gal (2022). In this respect, the workshop functioned less as an exercise in illustration and more as a form of enquiry.

6. Conclusion

The *Bugonia* workshop indicates that the combined use of poster analysis and digital intervention can operate as a concise yet conceptually grounded model of environmental image pedagogy. Rather than approaching interpretation as the extraction of pre-existing meaning, the distinction between declarative and poetic symbols enabled students to engage with images across shifting registers of stability and openness. In this context, transformation did not simply extend analytical observation, but reconfigured it, foregrounding interpretation as an active and materially situated process. Ecological meaning, therefore, does not reside within the image as content awaiting recognition. It emerges through situated practices of looking, altering and comparison, where meaning is continuously negotiated rather than fixed. What becomes visible through this process is not a resolved narrative of renewal, but a more complex condition in which persistence and vulnerability coexist. Renewal appears less as restoration than as a fragile continuity under pressure, marked by instability, exposure and ongoing transformation. In this sense, the workshop suggests that visual pedagogy can move beyond representational clarity towards forms of engagement that sustain ambiguity, allowing ecological relations to be encountered as dynamic, relational.

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BETWEEN EXPECTATIONS AND RECOGNITION: PERCEPTIONS OF PRESCHOOL TEACHERS' PROFESSIONAL STATUS AND THE PATH TOWARD TRANSFORMATION WITHIN THE TEACH-MC PROJECT

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Abstract

In the context of contemporary challenges in early childhood education and care (ECEC), this pilot study explores the perceptions of preschool teachers and parents regarding the status of preschool teachers. The aim was to identify key factors shaping its social positioning and to examine differences between key stakeholder groups. The study included 125 participants (59 preschool teachers and 66 parents) from a public kindergarten institution in Rijeka. Data were collected via an online questionnaire using an adapted version of the Status Scale (Šteh, Čepić & Kalin, 2017), piloted on a sample of preschool teachers and parents, with the results informing its refinement for subsequent use within the TEACH-MC Project. Quantitative data was analysed using descriptive and inferential statistical approaches to examine group differences and relationships with key sociodemographic variables. The findings indicate significant differences between the two groups, with preschool teachers perceiving their status as lower, while parents maintain a more favourable view. A notable discrepancy emerges in perceptions of social recognition and respect, suggesting differing expectations and a potential communication gap between stakeholders. Higher levels of education among preschool teachers are associated with more critical perceptions, pointing to a mismatch between increasing professional demands and societal recognition. This study forms part of the TEACH-MC Project (2025–2029) and represents its pilot phase, providing initial findings that inform its further development. The results contribute to the development of evidence-based recommendations aimed at strengthening the status and long-term sustainability of the profession.

Keywords: *Preschool teachers, status, teacher identity, TEACH-MC project, professional development.*

1. Introduction

Despite the established scientific consensus on the crucial role of early childhood education and care in children's holistic development, the preschool teaching profession continues to occupy a marginalized position and is associated with a lower social status compared to other educational professions. It is characterized by a paradox between its recognized societal importance and its relatively low level of social valuation, insufficient recognition of professional competencies, and demanding working conditions (Chan, 2019; Chong & Lu, 2019; Majerčíková & Urbaniecová, 2020). Low salaries, limited opportunities for career advancement, and the reduction of the professional role to care and basic childcare further undermine the status of the profession, while its educational dimension is often overlooked (Harwood & Tukonic, 2016; Majerčíková & Urbaniecová, 2020). Comparative research indicates significant differences in the perception of professional status, shaped by cultural context, educational systems, and societal values (Arnold & Rahimi, 2024; Chong & Lu, 2019). In many contexts, including Croatia, the profession faces ongoing challenges related to marginalization and declining interest in entering the field, further intensified by a global shortage of educational professionals (Flores, Oliveira & da Ponte, 2025). Empirical findings show that preschool teachers tend to perceive their professional status as lower than parents do, while the general public often fails to recognize the complexity of their work (Vu et al., 2023; Wong, 2022). Low status is associated with professional insecurity, lower job satisfaction, and potential implications for the quality of educational practice (Šteh, Kalin & Čepić, 2017, Čepić & Kalin (Eds.), 2019; Jurčević Lozančić, Tot & Kudek Mirošević, 2023).

In this context, the aim of this study was to examine the attitudes of preschool teachers and parents toward the status of the preschool teaching profession in a preschool centre of Kindergarten Rijeka (Primorje-Gorski Kotar County, Republic of Croatia), in order to gain a deeper understanding of the

position and role of preschool teachers within the educational system. The findings indicate the need for a more systemic approach to this issue. In response, the TEACH-MC Project (2025–2029) was developed and is briefly outlined in this paper. This study represents the pilot phase of one segment of the project and provides initial findings that inform its further development.

2. Purpose, aim and research questions

The purpose of this study was to contribute to a better understanding of the status of preschool teachers in early childhood education and care by examining the perceptions of preschool teachers and parents in order to gain insight into their social position and role within the contemporary education system. The aim of the study was to examine the attitudes of preschool teachers and parents toward the status of the preschool teaching profession and to identify key factors influencing its formation within social and professional contexts.

The study addressed the following research questions: (1) What are the basic descriptive indicators and metric characteristics of the instrument used to assess perceptions of preschool teachers' status? (2) Is there a correlation between participants' scores on the status scale and selected sociodemographic variables? (3) Are there differences between preschool teachers and parents in their perceptions of the status of the preschool teaching profession?

3. Methods

3.1. Participants

A total of 125 participants were included in the study, comprising 59 preschool teachers and 66 parents from the Turnić Preschool Education Centre within Kindergarten Rijeka. A convenience sample was used, including participants who were willing to take part at the time of data collection. The sample included parents from four and preschool teachers from six sub-centres. In the total sample, the mean age was (M = 38.57, SD = 9.01). Most participants were female (86.10%), while 12.80% were male and 0.80% preferred not to disclose their gender. Most held a master's degree (43.20%), followed by a bachelor's degree (20.00%), a professional undergraduate degree (16.80%), and secondary education (16.00%); a small proportion held a scientific master's degree (2.40%) or a doctoral degree (1.60%). Among preschool teachers, 98.31% were female and 1.69% male (M = 39.61, SD = 11.59). A total of 33.90% held a university graduate or undergraduate degree, 27.12% a professional undergraduate degree, and 5.09% secondary education. Among parents, 75.86% were female, 22.73% male, and 1.70% preferred not to disclose their gender (M = 37.64, SD = 5.45). Educational attainment among parents was distributed across all levels of education. Most parents had two children (51.52%), followed by one (42.42%) and three or more (6.06%). The majority were married or cohabiting (96.97%), while 3.03% were single. Most assessed their socioeconomic status as medium (69.70%), followed by high (21.21%), while none reported low status.

3.2. Instruments

Data were collected using an online questionnaire that included an adapted version of the Scale of Reputation (Šteh, Kalin & Čepić, 2017), referred to as the Status Scale. The scale was adapted to the context of early childhood education and care by replacing the terms teacher and teaching profession with preschool teacher and preschool teacher profession in all items, while one item was completely replaced with a newly formulated statement. The scale consists of eight items, including four positively and four negatively worded statements assessing the status of the preschool teaching profession. Participants indicated their level of agreement using a five-point Likert-type scale (1 = strongly disagree to 5 = strongly agree).

To examine the factor structure and metric characteristics of the instrument, an exploratory factor analysis was conducted using principal component analysis with oblique (oblimin) rotation. A two-factor structure was identified in the total sample, with the first factor explaining 30.30% and the second factor 18.90% of the total variance (49.20% in total). The scree plot and parallel analysis confirmed the two-factor solution, while factor loadings and communalities are presented in Table 1.

The internal consistency of the first factor was acceptable (Cronbach's $\alpha = 0.654$), whereas the second factor demonstrated low reliability (Cronbach's $\alpha = 0.361$). Consequently, only the first factor (The Low Status Scale) was retained for further analyses. This factor comprises the first four items and reflects aspects related to the negative perception of the preschool teaching profession, including low salaries, low social status, negative media representation, and lower job satisfaction.

Table 1. Factor loadings and communalities for the Status Scale.

Total sample (N = 141)			
	Factor loading		Communality
	F1	F2	
1. In the preschool teacher profession, salaries are lower than in other equally demanding jobs with an equal degree of education.	0,727	0.058	0,528
2. The preschool teacher profession enjoys a low status in society.	0,620	0.284	0,440
3. The media usually portray preschool teachers in a negative light.	0,588	-0.026	0,347
4. The low status of the preschool teacher profession affects job satisfaction.	0,648	-0.142	0,447
5. Preschool teacher's work is among the most important ones in society.	0,643	0.284	0,479
6. Preschool teachers respect parents.	0,336	0.754	0,660
7. Parents respect preschool teachers.	-0.283	0.751	0,662
8. The preschool teacher profession provides regular income and financial independence.	-0,367	0.474	0,374
Eigenvalues	2.478	1.459	
% of explained variance	30,30	18,90	

3.3. Data collection and analysis

Data were collected online using a Google Forms questionnaire administered to a convenience sample of preschool teachers and parents who voluntarily participated in the study. Participation was anonymous and voluntary, and all participants were informed about the purpose of the study prior to data collection. Data was analyzed using JASP statistical software (version 0.18.3). Descriptive statistics were calculated, and group differences between preschool teachers and parents were examined using the Mann–Whitney U test. Spearman's rank-order correlation was used to assess relationships between scores on the Status Scale and selected sociodemographic variables.

4. Results and discussion

4.1. Descriptive findings related to the status scale

Descriptive analysis indicates that preschool teachers scored higher on the Low Status Scale (M = 3.764, SD = 0.659) compared to parents (M = 3.299, SD = 0.862), suggesting a more critical perception of the profession's status. The highest mean score was observed for the item related to low salaries (M = 4.072, SD = 1,071), while the lowest was associated with media representation. The Mann–Whitney U test revealed a statistically significant difference between preschool teachers and parents in their evaluation of the profession's social status, with preschool teachers expressing more negative perceptions. No significant differences were found for the remaining items. All results are presented in Table 2.

The findings indicate that preschool teachers assess their own professional status significantly more critically than it is valued in society, which is consistent with previous research (Majerčíková & Urbaniecová, 2020; Vujičić, Boneta & Ivković, 2015). The perception of low salaries emerges as a key determinant of low professional status (Chan, 2019; Chong & Lu, 2022).

The absence of significant differences regarding media representation and job satisfaction suggests that these factors are not perceived as primary determinants of professional status, although the literature highlights their broader impact (Flores, Oliveira & da Ponte, 2025). Overall, the results point to a gap between preschool teachers' professional self-perception and societal evaluation of the profession.

Table 2. Descriptive statistics and group differences for the Low status scale items.

Items	Total sample M(SD)	Preschool teacher M(SD)	Parents M(SD)	U	p	Biserial corr.
1. In the preschool teacher profession, salaries are lower than in other equally demanding jobs with an equal degree of education.	4.072(1.071)	4.203(1.013)	3.955(1.115)	2190.500	0.199	0.125
2. The preschool teacher profession enjoys a low status in society.	3.472(1.154)	3.881(1.019)	3.106(1.152)	**2673.500**	**<.001**	**0.373**
3. The media usually portray preschool teachers in a negative light.	2.768(1.115)	2.915(1.022)	2.636(1.185)	2208.500	0.177	0.134
4. The low status of the preschool teacher profession affects job satisfaction.	3.592(1.178	3.695(1.178)	3.500(1.180	2115.500	0.389	0.087

4.2. Correlations with sociodemographic variables

Spearman's rank-order correlation was used to examine the relationships between scores on the Low Status Scale and sociodemographic variables due to non-normal data distribution. In the subsample of preschool teachers (N = 59), a strong positive correlation was found between age and years of experience ($\rho = 0.811$, $p < .001$), alongside moderate negative correlations between age and education ($\rho = -0.454$, $p < .001$) and between years of experience and education ($\rho = -0.402$, $p < .01$). A statistically significant, albeit weak, positive correlation was observed between education level and low status scores ($\rho = 0.284$, $p < .05$), indicating that more highly educated preschool teachers perceive the professional status as lower. No significant correlations were found for other variables.

These findings suggest that higher levels of education are associated with more critical perceptions of professional status, consistent with research highlighting the role of formal education in fostering reflective and critical perspectives (Wong, 2022; Yu, An & Zhao, 2023). In contrast, the absence of associations with age and professional experience indicates that perceptions of status are shaped less by experience and more by broader professional and societal contexts.

4.3. Group differences between preschool teachers and parents

An independent samples t-test was conducted to examine group differences. The results revealed a statistically significant difference between preschool teachers and parents, $t(123) = 2.705$, $p < .010$, with preschool teachers reporting higher scores on the Low Status Scale ($M = 3.746$, $SD = 0.659$) compared to parents ($M = 3.299$, $SD = 0.862$), indicating a more critical assessment of their professional status. These findings confirm the existence of a gap between preschool teachers' professional self-perception and the societal evaluation of the profession, with preschool teachers highlighting insufficient recognition of their expertise by parents (Chan, 2019; Jurčević Lozančić, Tot & Kudek Mirošević, 2023). The results are consistent with previous research indicating that preschool teachers tend to evaluate their professional status more negatively than parents and the wider public (Majerčíková & Urbaniecová, 2020; Blanuša Trošelj, 2024).

The findings of this pilot study highlight the need for a more systematic and comprehensive approach to understanding and improving the status of preschool teachers within early childhood education and care. The identified differences between preschool teachers and parents, as well as the association between higher levels of education and more critical perceptions, point to broader structural challenges within the profession. This study forms part of the TEACH-MC Project (2025–2029) and represents the pilot phase of one of its segments, providing initial evidence to inform its further development. The project adopts a systemic approach to examining factors influencing the attraction and retention of preschool and primary teachers across key stages of professional development, including entry into the profession, initial teacher education, and retention in practice. Particular emphasis is placed on understanding young people's motivations for career choice, as well as on strengthening the social status and long-term sustainability of the teaching profession. In this context, the findings offer important empirical insight into the perception of professional status as a key factor shaping both the attractiveness of the profession and retention. The TEACH-MC Project thus provides a research and development framework for addressing challenges related to the status and sustainability of the profession in a systematic and evidence-informed manner.

5. Conclusion

The findings point to a pronounced gap between the societal importance of early childhood education and care and the perceived status of the preschool teaching profession, the reduction of which is essential for ensuring the quality and sustainability of the system. While the results should be interpreted within the context of the study design and its pilot nature, they provide relevant insights for improving professional status. In this regard, the TEACH-MC Project (2025–2029) offers an important framework for systematically addressing issues related to the attraction and retention of preschool and primary teachers. Addressing these challenges requires improvements in working conditions, educational standards, and public perceptions of the profession, alongside stronger media representation and efforts to challenge persistent stereotypes. Investing in the status of the preschool teaching profession ultimately represents an investment in the quality and long-term sustainability of the education system.

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DOES FINNISH EDUCATION SYSTEM MATTER FOR CHOOSING FUTURE CAREER PATH? A COMPARATIVE STUDY AMONG THE EIGHTH GRADERS

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Abstract

The Finnish education system is one of the most effective educational systems in the world. It stands out for its strong emphasis on developing critical thinking and practical skills, as well as for its highly trained teachers and attention to student well-being. All these factors, along with others not previously specified, contribute to providing high-quality education for all students, regardless of their background. Since the world we live in is dominated by constantly evolving technology, students need an education that provides equal opportunities for everyone and helps them prepare for future careers in an unpredictable labor market. This study was motivated by the need to identify the particularities of the Romanian and Finnish education systems and how they influence the career choices of 8th-grade students. The study involved 68 students from two schools in Bucharest. Both schools follow the Romanian national curriculum, but one of them applies practices inspired by the Finnish education system. The purpose of this study was to explore whether Finnish-style education influences the career choices of 8th-grade students. The data for the study were collected using a STEM identity identification tool developed by researchers (STEMI – STEM Identification instrument). The results of the data analysis show that the Finnish education system has clear benefits and influences the way students develop their STEM identity. The study also presents certain limitations, including the small number of students and schools included, as well as the lack of longitudinal data. Finally, recommendations were made for pre-university teachers and educational policymakers regarding the improvement of the education system through the integration of STEM subjects and the implementation of methods and strategies that help students develop their STEM identity.

Keywords: *Finish education, career, eighth grade, Romania, STEM.*

1. Introduction

In recent years, digitalization has been shaping the overall structure of education worldwide, drawing the attention of researchers, practitioners, and decision-makers regarding educational development. Digital technologies can transform both the field of education and the labor market in terms of the skills required (Qureshi et al., 2021).

STEM workers (science, technology, engineering, mathematics) contribute to national innovation and competitiveness by generating new ideas, companies, or industries (Langdon et al., 2011). In this era characterized by rapid technological progress and a transforming global economy, preparing students for future jobs is essential. STEM education has become the foundation that provides students with the skills and knowledge necessary to excel in a competitive environment (Doly, 2024).

Finnish students have stood out for their performance in every field since 2000, from the first edition of the Programme for International Student Assessment (PISA). Finland was one of the countries that achieved the highest results and demonstrated an exceptional level of educational equity, with high academic and social inclusion as well as a large proportion of resilient students (Ustun & Eryilmaz, 2018).

2. Literature survey

Educational policies in Finland have been designed to enhance student performance and are built on concepts of sustainable leadership, with an emphasis on teaching and learning, intelligent responsibility, and encouraging schools to create optimal learning environments and implement educational content that motivates students to achieve the general objectives of education (Sahlberg, 2007).

The Finnish education system's main goal is to provide valuable learning experiences that develop communication skills, improve independent and critical thinking, broaden students' global perspective, and build self-confidence. Finnish methods encourage group learning, a reduced volume of homework, and a stronger focus on student well-being and collaboration. Thus, the Finnish educational approach values student-centered learning; the relaxed school environment fosters collaboration and gives students the opportunity to develop life skills and problem-solving abilities (Mandavkar, 2024).

In an era where society is becoming increasingly dependent on technology and science, a declining interest in STEM careers can be a cause for concern. A study analyzing predictors of students' interest in STEM careers using data collected from 601 students in Finnish general upper secondary schools showed that receiving career information from multiple sources can have a positive effect on interest in STEM careers. Furthermore, students' beliefs about their self-efficacy in mathematics positively correlate with interest in scientific subjects, which in turn contributes to their interest in STEM careers (Kaleva et al., 2023).

In Romania, 26% of students enrolled in tertiary education are in STEM fields, compared to an EU average of 32%. Therefore, identifying the factors that maintain student engagement and examining their motivations was the starting point for a study conducted on a sample of 548 students from a technical university in Bucharest. The data showed that intrinsic motivation (34.74%) and career opportunities (36.16%) drive the students' main choices. Additionally, 71.39% of the students associated STEM engagement with an enhanced sense of well-being (Dogaru et al., 2025).

A study analyzing the methods and strategies used to prepare students for successful careers in Romania indicated that integrating real-life experiences through practical training, developing critical thinking and problem-solving skills, promoting lifelong learning, and personal development have a significant impact on preparing young people for successful careers in a continuously changing society (Grigorescu, 2024).

Another study examining the quality of higher education, focusing on the question "Are graduates prepared for the labor market?", highlighted the employers' perspective. The results showed that while diplomas are valuable, graduates possess more theoretical knowledge than practical skills. To reduce this gap, universities need social engagement and well-designed strategies to support students in the employment process. Specifically, a stronger connection between the theoretical education provided by universities and the practical requirements of employers is necessary, achievable through programs that develop students' soft and applied skills, thus preparing them for the labor market (Stanciu & Banciu, 2012).

3. Methodological approach

The research methodology was quantitative and was designed to explore the impact of educational approaches on the career choices of eighth-grade students. The main research question was whether Finnish educational practices influence students' STEM identity and their preferences regarding future careers, compared to traditional education in Romania. The study involved 68 students from two schools in Bucharest, Romania, both following the national curriculum. One of the schools, hereinafter referred to as Group 1, operates based on certain practices inspired by the Finnish education system, emphasizing collaborative learning, reduced homework volume, participation in community events and extracurricular activities, and student-centered learning. The other school, hereinafter referred to as Group 2, is a traditional Romanian school. Group 1 included 31 students, and Group 2 had 37 students, all aged between 13 and 14 years.

Data were collected using a questionnaire developed by the authors, called the STEM Identification Instrument (STEMi). This instrument is designed to assess students' interest in exploration, experimentation, logic, and technical thinking (early STEM indicators), as well as evaluate communication, collaboration, autonomy, and strategic thinking skills, measure motivation and attitude toward STEM, and assess specific STEM competencies and knowledge (mathematical reasoning, problem-solving, etc.). The questionnaire included both closed and open-ended items. Some items allowed students the freedom to provide their own responses. It was structured into four dimensions, comprising a total of ten items. The first dimension measured students' interest in STEM, the second focused on students' attitudes toward STEM, the third assessed students' STEM-related competencies, and the final dimension consisted of questions on vocational reflection. The data collected from the two student groups were compared to determine whether students in Group 1, learning within a Finnish-inspired system, demonstrated a stronger STEM identity and greater interest in STEM careers.

4. Findings

To measure students' interest in STEM from childhood, they were asked how they preferred to spend their free time. Most of them—21 from the first group and 25 from the second group—chose "outside, in the open air, at the playground." This response indicates that students favored physical and social activities, with exploring the surrounding environment serving as a foundation for developing later interest in science. Regarding structured STEM activities, such as Lego constructions, puzzles, and models, 6 students from the first group and 7 from the second group chose this option. For activities like reading, drawing, and coloring, only 4 students from the first group and 1 from the second group selected this. Additionally, 4 students from the second group preferred to create their own activities, such as sports, robotics, or video games. Therefore, during childhood, most students were oriented toward recreational outdoor activities, while STEM activities, even if chosen by fewer students, indicate that some displayed an early interest in this field and needed support to maintain and develop their STEM skills.

To assess students' interest in exploration and curiosity, they were asked what they think about when looking at a device. Most students from the first group (27) said they wondered how it works. Similarly, 23 students from the second group chose the same answer. This indicates that children had a high level of curiosity in childhood, which should be nurtured to sustain their interest in exploration.

Regarding students' communication and collaboration skills, they were asked what they prefer to do during a practical activity or experiment. Most students in the first group (20) preferred to collaborate with peers to achieve their objective. In contrast, most students in the second group (18) preferred to find a solution on their own. These results suggest differences in task approaches: students in the first group demonstrated more developed communication and collaboration skills, favoring teamwork, while students in the second group leaned toward independent problem-solving. This supports the idea that the Finnish educational system, by fostering a sense of community and emphasizing collaborative activities, helps students understand the importance and benefits of teamwork, thereby developing cooperation, communication, and mutual support skills essential in education and everyday life.

Next, students were asked to choose how they respond to obstacles in their activities. Most students in the first group (12) chose "I try to solve it on my own until I find a solution," and the same option was chosen by most students in the second group (18). A notable difference was in the "ask for help immediately" option: only 2 students from the first group chose this, compared to 8 from the second group. This suggests that students in the first group have higher self-confidence and frustration tolerance. Another difference appeared in "seek additional information and resources to help me," chosen by 10 students in the first group and 6 in the second. Regarding collaboration with peers to find a solution, 6 students in the first group and 4 in the second chose this. These small differences indicate that while most students prefer to try solving problems independently, students in the first group are more inclined to seek additional information and collaborate with peers to overcome obstacles.

The next section of the questionnaire measured students' interest and motivation in STEM. Students were offered statements to agree with. Although differences were not significant, the open-ended responses at the last item revealed that students in the first group aspired to careers in engineering, physics, biology, technology, construction, entrepreneurship, or sports. Some also mentioned wanting careers that allow them to help people, work with children, or develop their creativity. Students in the second group were more interested in careers in psychology, policing, acting, sports, or fields that provide opportunities to discover new things. Thus, both groups demonstrated interest and motivation toward STEM, but differences in career preferences were observed: students in the first group leaned more toward STEM careers, while those in the second group mentioned careers in other areas. These differences likely reflect the type of career guidance the students received.

The following section assessed students' logical thinking, mathematical reasoning, and problem-solving skills. Students were given three problems. The first problem measured mathematical competence and logical thinking. In both groups, most students correctly solved both requirements of the problem: 27 students in the first group solved the first part correctly and 28 the second, while 29 students in the second group solved both correctly. Therefore, both groups demonstrated well-structured mathematical and logical skills.

The second problem measured the students' ability to apply mathematical concepts in problem-solving, especially mathematical reasoning, geometry, and optimization skills. Differences emerged between the groups. For the first requirement, 4 students from the first group answered correctly, 4 partially correctly, 14 incorrectly, and 9 did not answer; in the second group, 2 answered correctly, 12 incorrectly, and 23 did not answer. For the second requirement, the first group had 20 incorrect and 11 unanswered responses, while the second group had 3 correct, 10 incorrect, and 24 unanswered. Thus, students in the first group demonstrated a medium level of understanding of geometry and optimization,

with more correct or partially correct answers, whereas students in the second group had more incorrect or unanswered responses, indicating greater difficulty in applying mathematical concepts in practice.

The final problem focused on students' ability to apply mathematical and physics concepts in real-world contexts. All students faced significant difficulties in applying math and physics knowledge practically, but students in the first group had more correct and partially correct answers for parts a, c, and d. Students in the second group had the highest percentage of unanswered questions, indicating a lack of understanding or hesitation in solving applied problems.

Table 1. Student results on practical math and physics problem.

	a		b		c		d	
SCORE	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2
correct	19	8	2	2	2	-	16	3
partially correct	-	-	-	-	16	1	1	-
incorrect	1	2	17	7	1	7	1	3
no answer	11	27	12	28	12	29	13	31

The next section focused on questions related to vocational reflection. First, students were asked whether they were considering a career in STEM. Both groups included students who expressed interest (6 students from the first group and 8 from the second) as well as students who were not interested (16 students from the first group and 8 from the second). Additionally, in the first group, 6 students did not answer and 3 were undecided, while in the second group, 15 students did not provide a response. Therefore, these answers do not show major differences between the two groups, especially given the number of students who did not respond.

Finally, students were asked how they felt their school had prepared them for a career in STEM. Responses from the first group were varied, including the listing of STEM subjects studied at school, participation in various projects and experiments, extracurricular activities, and the development of resilience and critical thinking. However, in the first group, 7 students did not answer and 3 stated that their STEM preparation had been weak. Students in the second group mainly listed the STEM subjects they had studied. Additionally, 15 students did not respond, and 9 stated that they had not been prepared or did not know how to answer. Thus, students in the first group perceive their STEM preparation as more comprehensive, including projects, experiments, extracurricular activities, and the development of various necessary skills, whereas students in the second group mainly cited classroom subjects and had more negative or unanswered responses, indicating a more limited perception of the school's STEM preparation.

5. Limitations and further steps

The main limitations of the study are the small sample size (68 students) and the inclusion of only two educational institutions. These factors limit the generalization of the results to the entire student population in Bucharest or Romania. Additionally, the cross-sectional design of the study does not allow for monitoring long-term changes in STEM identity or career preferences. Nevertheless, the results obtained can be useful for teachers, students, parents, and educational staff in optimizing the career guidance process and fostering students' STEM identity. Future research should involve a larger sample and include longitudinal studies to identify trends over time, monitor skill and interest development, and evaluate the lasting effects of educational practices on career choices.

6. Discussions and recommendations

The study shows that educational practices inspired by the Finnish system promote student collaboration, problem-solving, autonomy, and increased interest in technical and scientific fields. Therefore, the authors' recommendations for teachers include fostering collaboration among students through classroom and extracurricular activities, project-based learning, encouraging learning through experimentation, developing critical thinking, and maintaining students' curiosity. Regarding recommendations for school leadership, these include offering a diverse range of extracurricular activities, emphasizing the balance between learning and student well-being, and promoting learning through experimentation. Additionally, educational policymakers should adapt curricular approaches to be student-centered, train teachers in innovative methods, and support research on long-term career impacts. Altogether, these measures can contribute to creating a better learning environment where students can grow personally and prepare effectively for future careers.

7. Conclusions

Thus, according to the results presented above, students exposed to educational practices inspired by the Finnish system (Group 1) demonstrate more developed communication and collaboration skills, greater frustration tolerance, and higher self-confidence compared to students in the traditional Romanian school (Group 2). They also show higher levels of autonomy and perseverance, more frequently seek additional information, and collaborate more effectively with their peers. The results of the math and physics tests indicate that both groups possess basic knowledge, but students in Group 1 provided more correct and partially correct answers, showing a better ability to apply concepts in real-world contexts. Regarding interest in STEM fields, students in Group 1 displayed greater motivation and a clearer orientation toward engineering, physics, chemistry, and construction, whereas students in Group 2 were more drawn to non-STEM fields. Furthermore, the preparation provided by the school for students in Group 1 is more diverse, including projects, experiments, and extracurricular activities, while students in Group 2 mentioned only the subjects studied during regular classes.

Therefore, practices inspired by the Finnish educational system contribute to the development of STEM identity and positively influence students' interest in STEM careers, providing them with better preparation for practical application of concepts and a clearer orientation toward a STEM career.

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IMPLEMENTING A STEAM-ORIENTED HANDS-ON CURRICULUM IN GENERAL EDUCATION COURSES

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Abstract

This study was conducted within a general education course at National Taitung Junior College and aimed to design and implement an interdisciplinary, hands-on curriculum grounded in the principles of STEAM (Science, Technology, Engineering, Arts, and Mathematics). Through context-based learning and a design thinking approach, students were guided to integrate scientific inquiry, engineering design, mathematical analysis, and artistic creativity to address real-world problems, thereby fostering creativity, problem-solving skills, and interdisciplinary competencies. The curriculum was structured around thematic activities such as sensor system design, solar-powered vehicles, voice sensing applications, and water rocket system design. These activities integrated sensor applications, data collection and analysis, structural design, and aesthetic expression. Beyond functional implementation, students were encouraged to consider visual design, creative expression, and usage scenarios of their projects. The instructional process emphasized teamwork, iterative prototyping, and reflective revision, enabling students to comprehend abstract concepts through hands-on practice while developing communication and presentation skills through project demonstrations and oral presentations. The research methodology primarily employed a STEAM learning outcomes questionnaire and classroom observations to analyze students' learning interests, knowledge application, reasoning and analytical abilities, and creative performance. The results indicate a positive improvement in students' learning attitudes and engagement across all STEAM dimensions. In particular, students demonstrated significant learning gains in transforming mathematical and engineering concepts into tangible design outcomes and enhancing project completeness and expressiveness through the integration of artistic elements. Overall, the findings suggest that incorporating STEAM-based interdisciplinary practices and artistic design elements into general education courses not only enhances students' understanding of and interest in STEM learning but also contributes to the development of creative practice and real-life application skills. This study provides a practical and replicable model for promoting STEAM education and instructional innovation in technical and vocational higher education institutions.

Keywords: *STEAM education, interdisciplinary learning, general education, design thinking, hands-on learning.*

1. Introduction

In recent years, STEAM education has emerged as a key approach to fostering interdisciplinary competencies and innovation in education. By integrating science, technology, engineering, arts, and mathematics, STEAM emphasizes real-world problem solving and holistic learning experiences (Yakman, 2008; Yakman & Lee, 2012). Compared with traditional STEM education, STEAM incorporates artistic design elements to enhance creativity and expressive capacity.

Previous research has indicated that STEAM-based learning can significantly improve students' motivation, engagement, and interdisciplinary competence, particularly in science and engineering domains (Herro et al., 2018). Furthermore, the integration of problem-based and inquiry-based learning approaches supports the development of critical thinking and collaborative skills (Barron & Darling-Hammond, 2008).

In technical and vocational education, general education courses play a crucial role in cultivating students' foundational competencies. However, traditional teaching approaches often focus on knowledge transmission, limiting students' ability to apply knowledge in real-world contexts. Therefore, this study introduces a STEAM-oriented hands-on curriculum to enhance students' learning motivation, interdisciplinary integration, and creative performance.

2. Design

STEAM education originated from STEM education initiatives in the 1990s and later incorporated artistic elements to form a more comprehensive interdisciplinary framework (Yakman, 2008). It emphasizes knowledge integration rather than isolated subject learning and highlights authentic contexts, interdisciplinary competence, and innovative design.

This study adopts both design thinking and problem-based learning as instructional frameworks. Design thinking involves five stages: empathize, define, ideate, prototype, and test (Brown, 2008). This process enables students to actively identify problems and develop solutions through iterative refinement.

The course was designed around four modules: sensor system design, solar-powered cars, voice sensing, and water rocket systems. These modules integrate real-life applications and combine scientific principles, technological tools, engineering design, mathematical analysis, and artistic creativity.

Students engaged in hands-on activities involving data collection, system construction, and iterative testing. The course emphasized teamwork, reflective learning, and project presentation to enhance communication and collaboration skills.

3. Objectives

The objectives of this study are as follows:

(1) To develop a STEAM-oriented interdisciplinary curriculum for general education.
(2) To enhance students' learning motivation and engagement.
(3) To improve students' problem-solving and creative abilities.
(4) To examine the role of artistic design in STEM learning.
(5) To evaluate students' ability to apply interdisciplinary knowledge in practical contexts.

4. Methods

This study adopted a mixed-method approach. Participants were students enrolled in a general education course at National Taitung Junior College.

Data were collected through a STEAM learning effectiveness questionnaire, classroom observations, and interviews. The questionnaire measured learning interest, knowledge application, reasoning ability, and creative performance. Observations and interviews provided qualitative insights into students' engagement and learning processes.

Descriptive statistical analysis was conducted to evaluate learning outcomes, complemented by qualitative analysis to interpret students' experiences.

5. Discussion

The findings indicate positive improvements in students' learning attitudes and engagement, with mean scores ranging from 4.4 to 4.6 across STEAM dimensions. Most students expressed interest in the course and willingness to participate in similar learning experiences.

Qualitative data revealed that students were able to apply mathematical and engineering concepts to practical design tasks, such as voice recognition systems and water rocket projects. The integration of artistic elements enhanced the creativity and completeness of their work.

However, some students encountered challenges in mathematical calculations and technical implementation, suggesting the need for additional instructional support and scaffolding.

Overall, the results demonstrate that STEAM education effectively bridges theory and practice, promoting interdisciplinary learning and problem-solving skills.

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6. Conclusions

This study demonstrates that STEAM-oriented hands-on learning can significantly enhance students' learning outcomes in general education courses. The integration of artistic design elements improves creativity and project quality, while contextualized learning and design thinking approaches support real-world application.

The proposed instructional model is practical and feasible, providing valuable insights for implementing STEAM education in technical and vocational institutions. It contributes to the development of interdisciplinary education and innovation in teaching practices.

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FUTURES LITERACY AS AN INCLUSIVE CONCEPT

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Abstract

The contribution takes a theoretical and conceptual perspective. First, the learning requirements associated with social innovations and crisis events are examined in order to clarify the challenges they pose for individuals and society. In the next step the concept of Futures Literacy (UNESCO, 2021; 2026) will be introduced, which is considered as a central concept for dealing with complex, uncertain and dynamic situations. However, promoting Futures Literacy presents a number of educational challenges: On the one hand, the future is a difficult subject to grasp. On the other hand, developing future scenarios requires certain skills that some learners have yet to acquire. Since the concept is fundamentally relevant to all people, the article explores the overarching question of the extent to which Futures Literacy is an inclusive approach that also enables disadvantaged individuals to participate in the process of shaping the future. For this purpose, contemporary didactic approaches to promoting Futures Literacy are presented and discussed from an inclusive education perspective.

Keywords: *Didactics, future, futures literacy, future skills, inclusive education.*

1. Introduction and problem definition

The present is characterized by rapid technological progress and numerous crisis events that require innovative action in all areas of society and are accompanied by new learning requirements for society and individuals. The numerous current processes of change cannot be comprehensively described here. Examples include global megatrends such as “digitalization, internationalization, individualization, and demographic change” (Kauffeld & Albrecht, 2021, p. 4) as well as “global economic and financial interdependence, migration, and climate change” (Schüller, Busch & Hindinger, 2019, p. 15).

Against the backdrop of current social change dynamics and, in some cases, crisis-ridden developments, the concept Futures Literacy (UNESCO, 2021; 2026) provides a key framework for developing future-shaping skills in complex, dynamic, and uncertain situations. It is considered a central approach to enabling individuals to better shape the future.

As all members of society are fundamentally affected by the social transformation processes mentioned above, Futures Literacy has to be considered as an inclusive approach. According to Allabauer (2022, p. 40) every individual is involved in the development of future-shaping skills. Sippl et al. (2023) point out that “futures literacy should enable each individual to develop strategies for coping with an uncertain future [...]. It encompasses an expanded perception and the ability to imagine alternative futures, the acceptance of complexity, and a new understanding of our capacity for action” (p. 9). In a broad understanding of inclusion Futures Literacy should incorporate social diversity and also give a voice to minorities, dissenting opinions, and critical voices (Bergheim, 2022, p. 278).

This article therefore explores the overarching question of the extent to which current didactic approaches to promoting Futures Literacy are suitable for meeting the requirements of inclusive and barrier-free education. The following section first examines the competence dimensions of Futures Literacy in order to identify starting points for competence acquisition on the one hand and pedagogical challenges on the other (chapter 2). Subsequently, exemplary didactic approaches for promoting Futures Literacy are presented and discussed in terms of inclusive education (chapter 3). The article concludes with suggestions for designing learning arrangements that are more strongly geared toward the needs of learners with special learning needs than has been the case to date (chapter 4).

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2. Futures literacy: Competence dimensions and educational challenges

The concept Futures Literacy was developed by UNESCO. It is defined as "a capability to help people understand how and why we use the future to prepare, plan and interact with complexity and novelty in our societies." (UNESCO, 2026). The skills it refers to are intended to enable people to stimulate their own imagination and thus improve their ability to recognise the significance of the future for their own lives, embrace change and shape social change (cf. UNESCO, 2021; 2026). The concept is considered to be a key approach to empowering individuals to shape the future more effectively (Allabauer, 2022, p. 39).

This is not an entirely new approach. Learning how to deal with change has long been a central topic e.g. in vocational training and education (Wittwer, 2011, p. 128f.). Back in 2011, Wittwer defined nine characteristics of *Change Competence*: commitment, curiosity, socially integrative behaviour, strategy, experience, composure, thoughtfulness, socially communicative action and willingness to change (p. 119f.).

Despite the central importance of the skills or competences addressed by Futures Literacy for dealing with social change and crisis phenomena, there is currently no uniform and binding understanding of this concept (Walter, 2024). Research literature has so far presented an inconsistent picture with regard to the definition of the competence dimensions associated with Futures Literacy. The concept encompasses different concepts of competence. This is reflected, for example, in the terms *skills* and *literacy*. These terms are mostly used synonymously in current research literature. In the following, the competence dimensions contained in the concept will be elaborated in more detail in order to derive conclusions for pedagogical and didactic questions and in order to be able to determine more precisely didactic starting points for the design of future-oriented teaching-learning settings.

2.1. Future skills

Future Skills are defined as "skills that will become significantly more important for working life or social participation in the next five years" (Kirchherr et al., 2018, p. 2). These include, for example, "the design of transformative technologies (artificial intelligence, smart hardware, robotics) as well as key digital and non-digital skills (digital interaction, adaptability, entrepreneurial thinking)" (ibid.). According to Suessenbach et al. (2021, p. 2) e.g., so-called *transformative skills* play a central role for companies and educational institutions alongside *classic*, *technological* and *digital skills*. In a competency framework presented in 2018, Kirchherr et al. identified a total of 18 Future Skills, which were divided into three categories: technological skills, basic digital skills and traditional skills (p. 5). Technological skills include competences "that are necessary for the design of transformative technologies" (ibid.). These skills are primarily required by specialists (ibid., p. 4 f.). Possessing basic digital skills, such as digital learning or agile working, enables people to "find their way around a digitalised environment and actively participate in it" (ibid., p. 5). These skills will be necessary in the future for both professional life and social participation ("digital citizenship"). They should therefore be mastered by everyone. Classic skills refer to things like problem-solving ability, creativity and perseverance (ibid.). In an extension of this Future Skills Framework from 2021, transformative skills were added as a fourth category, as these are becoming particularly important for companies in view of the key social challenges and accelerated change of recent years (Suessenbach et al., 2021, p. 4).

In summary, it is clear that Future Skills are a rather open and dynamic concept that is closely linked to current (technological) developments and is constantly changing. Definitions of Future Skills currently exist primarily as domain- or subject-specific frameworks (i.e. competence frameworks) that need to be specified for the design of educational processes. To this end, learning objectives must first be derived and competence levels defined (cf. Schüller et al., 2019, p. 50). One criticism could be that Future Skills is merely a "list of skill sets" (Ehlers, 2019, p. 37) based on a rather functionalist understanding of education. Futures Literacy, on the other hand, refers to more far-reaching skills, which will be discussed below.

2.2. Futures literacy

The meaning of the term *Literacy* has changed over time. The original understanding of Literacy refers to the mastery of classical cultural techniques such as reading, writing and mathematical thinking (Peschl, 2022). However, mastery of the original cultural techniques is no longer sufficient in today's "real and virtual world in which we live" (Allabauer, 2022, p. 40). In addition to a reflective approach to media, other cultural techniques are necessary to cope with social change (ibid.). Newer forms of Literacy include "personal, social and learning skills" (ibid.) as well as "critical thinking, the use of technology, social skills and the ability to empathise" (Peschl, 2022). This illustrates that the concept of literacy encompasses not only the ability to use certain technologies, but also the competence to adopt a reflective attitude and ask in-depth questions. This approach thus goes beyond the previously explained concept of Future Skills.

According to Peschl (2022) Futures Literacy means "engaging in a process of co-becoming with an unfolding reality" (n. p.). Co-becoming means reflecting on our relationship with the world and questioning that relationship. It also means engaging in "an exchange-oriented, interactive, existential, and cooperative relationship with the world" (ibid.). As an interim conclusion, it can be stated that Futures Literacy is more comprehensive than skills or competences: The above analysis, which does not claim to be exhaustive, shows that the dimensions listed here form a *holistic set* of skills, competences, and attitudes that enable us to deal better with future challenges and opportunities, both individually and collectively.

Promoting Futures Literacy also presents certain educational challenges: The future is something that does not yet exist. Consequently, the future is not tangible, but can only be grasped linguistically (cf. Grunwald, 2009, p. 26). The future can be derived from the present and the past. Anyone who wants to predict the future must know as much as possible about the present and the past (Gehmacher, 1968, p. 63; cited in Opaschowski, 2009, p. 17). Due to the language skills and prior knowledge required, some learners may need a special level of support in order to develop Future Literacy. Since this concept is a complex construct of different skills and competences, it can also be useful to determine different levels in order to identify starting points for support.

Since Futures Literacy is fundamentally relevant to all people, the question arises as to what extent the currently available didactic and methodological approaches are suitable for addressing the social diversity of learners. This question will be explored in the following chapter.

3. Didactic approaches to promoting Futures Literacy in educational practice

There are various didactic approaches and methods for promoting futures literacy (Bergheim, 2025), some of which are presented here as examples:

- **Future Workshop:** The classic future workshop was developed in Germany in the 1960s by Robert Jungk – "at the time of the civil rights movement as a method for solving social problems" (Meyer, 2019, p. 50). It is suitable for both school and extracurricular settings and promotes critical thinking, creative idea development and the ability to create action plans. The learning process comprises three phases. In the first phase, future topics and trends, as well as uncertainties and concerns, are analysed together. In the second phase, learners are encouraged to develop unconventional ideas and visions for the future based on the previous analysis. In the third phase, a concrete implementation plan is developed to help gradually realise the visions developed previously (Reich, 2003). In terms of content, the method is suitable for a wide range of topics (Holzinger & Spielmann, 2016).
- **Futures Literacy Laboratory:** The Futures Literacy Lab (FLL) was developed by UNESCO (2021; 2026). This is a structured and participatory learning format designed according to the principle of learning by doing. The FLL consists of four consecutive phases: *1. Reveal:* In this phase, participants explore their unconscious assumptions about the future, *2. Reframe:* Subsequently, new visions for the future are developed through targeted provocations or a change of perspective. Methods such as role-playing, visualisation or creative techniques are used for this purpose, *3. New Questions:* Based on the new visions of the future, questions about the present are reformulated, *4. Next Steps:* The newly acquired knowledge and perspectives are applied to current challenges (Scheerer, 2025).
- **Backcasting:** As part of this method, a desirable future goal is first defined. It then looks back and describes the steps required to achieve this goal (Krebs, 2024). This makes it possible "to circumvent existing assumptions and limitations of the present [...] and to focus on what is necessary to achieve long-term goals" (ibid.). Backcasting is particularly suitable for complex problems where small changes are not enough to achieve significant improvements. The method aims both to anticipate future problems and to identify the steps that need to be taken from the present in order to achieve this goal (ibid.).
- **Futures-Realcasting with eKursion:** This didactic approach was conceptualized by Angelika Neudecker (2024) as a "globally oriented and spatially focused extension of the Futures Laboratory" (p. 1). The method of Futures-Realcasting was developed in analogy to the method of Backcasting. Realcasting assumes "that a large part of the imagined futures actually already exist in the world (or are currently being developed, built, tested, or researched)" (ibid.). The aim of an eKursion is to find out to what extent the futures imagined in a Future Lab already exist in the real world. This is achieved using the Futures-Realcasting-Method, i.e. comprehensive research into the actual existence of the future visions developed. The eKursion promotes both the Futures Literacy of the participants and their *Cosmopoliteracy*, which is a "central competence of Education for Sustainable Development (ESD) and Global Learning" (ibid.).

- **Serious Games:** Serious games are increasingly becoming the focus of educational discussions. These are primarily digital games that are used to impart knowledge or encourage learners to engage with socially relevant topics. They combine playful elements with serious topics or learning content (Deutsche Kinder- und Jugendstiftung, 2026). Serious board games, e.g. Horizon Makers, can be used to promote "creative imagination, storytelling, sense-making, critical thinking, and empathy" (Schönbohm, 2025, p. 285).
- **Digital Games:** According to Walter (2024), digital games are a medium that can empower people to deal with future uncertainty. In his view, the specific media characteristics of games are well suited to teaching selected sub-skills of Futures Literacy, e.g. promoting innovative thinking and problem-solving skills (cf. Mills, Unworth & Scholes 2023, p. 66 f.). In this context, he draws on Candy (2018, p. 242) to highlight the potential of games to reduce complexity. Games open up spaces for action and exploration in which learners or players can try out new ways of acting without having to fear real-world (and possibly negative) consequences. In terms of content, his considerations focus on the climate crisis, which he believes to be the longest-lasting crisis of the present.

The approaches presented offer different starting points for promoting specific sub-skills and/or sub-competences of Futures Literacy. The following section discusses what adjustments may be necessary to the presented didactic approaches for promoting Futures Literacy for vulnerable or disadvantaged learner groups.

4. Conclusions

Promoting Futures Literacy, especially through constructivist methods, offers great potential for addressing social challenges that affect everyone. The ability to deal with future opportunities and uncertainties is particularly crucial for disadvantaged groups. In vocational education and training, Futures Literacy enables an inclusive approach to addressing future-related topics in the context of work and careers. It is important to consider the following aspects:

The methods presented above encourage participation and creativity, but also require social and communication skills. This could be problematic for participants with language barriers and requires special support measures. The use of digital media is equally motivating, but carries the risk of marginalizing people with insufficient digital skills.

In order to make Futures Literacy accessible to disadvantaged groups, learning content should be designed to be relevant to everyday life and accompanying support measures such as language courses must be offered. Given the social diversity in vocational training and a consolidated transition system in Germany, it is essential to actively involve disadvantaged groups in the discourse on the future. Adaptive (further) education and training opportunities are necessary to ensure that Futures Literacy is not only accessible to those from more education-oriented backgrounds.

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EMBEDDING AI LITERACY WITHIN DISCIPLINARY CURRICULUM THROUGH STRUCTURED ASSIGNMENT DESIGN

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Abstract

The rapid expansion of generative and agentic artificial intelligence (AI) in higher education is prompting renewed discussions about curriculum integration, academic integrity, and responsible technology adoption. While institutions debate policy and regulation, a central pedagogical question remains: how can AI literacy be embedded meaningfully within disciplinary coursework rather than treated as a standalone skill or external add-on? This paper explores an instructional design approach that integrates AI directly into structured course assignments while preserving disciplinary rigor. The discussion is grounded in the redesign of a specific undergraduate course assignment, used as a concrete example of discipline-embedded AI integration. Rather than positioning AI as a shortcut or replacement for student effort, the approach reframes AI as a tool that must be evaluated, constrained, and verified within existing learning objectives. In the redesigned assignment, students first demonstrate foundational competency independently before engaging generative AI to extend, analyze, and refine their work. Students document their prompts, test AI-generated outputs, identify inaccuracies, and justify revisions, ensuring that conceptual understanding remains central. The structured integration emphasizes that AI literacy involves understanding system limitations, critically evaluating outputs, and recognizing AI's influence on disciplinary thinking. By embedding AI use within established coursework, curriculum redesign becomes incremental rather than disruptive, allowing faculty to integrate AI without replacing core assignments. The paper will outline the design principles guiding this integration, including scaffolding, productive struggle, and transparent documentation, and will discuss how the model can be adapted across disciplines to support responsible AI adoption in higher education. As generative AI continues to influence academic work, instructional design plays a central role in shaping student engagement with these systems. Embedding AI literacy within disciplinary curriculum offers a sustainable pathway forward that balances innovation with rigor and prepares students to engage critically and ethically with emerging technologies.

Keywords: *AI literacy, curriculum integration, instructional design, generative AI, higher education.*

1. Introduction

Generative and agentic artificial intelligence (AI) systems are beginning to change the day-to-day reality of coursework in higher education. In technical courses especially, students now have easy access to tools capable of generating programming code, written explanations, database queries, and analytical responses within seconds. In many cases, the output looks convincing enough that students may assume it is correct before ever testing or evaluating it. This is starting to create some interesting challenges for pedagogy. Currently, many assignments in higher education are structured with the explicit goal of granting students insight into their level of understanding of course material. But as generative AI becomes more sophisticated, assignments like these are increasingly likely to reveal more about the efficacy of a prompt than the depth of knowledge that a student has acquired. To date, most of the conversation in higher education about the role of AI has to do with questions of academic integrity, authorship, and institutional policy. In an increasing number of contexts, students use a variety of tools to collect and analyse data outside of formal schooling and indeed outside of teacher control. The more immediate question for teachers and instructors is then how these tools can be used within the classroom so that students learn to evaluate and work through AI-generated outputs rather than simply relying on them uncritically (Holmes et al., 2019; Zawacki-Richter et al., 2019).

Of increasing interest as more educational tools incorporate AI into their functionalities, is the idea of AI literacy. Though there is still a lack of consensus when it comes to fully defining this term, it is generally considered to encompass knowledge of how AI systems operate, awareness of AI systems'

limitations, and a critical perspective when interacting with AI generated content (Ng et al., 2021). Discussions of AI literacy in academia tend to be separate from discipline specific coursework and typically encompass topics such as workshops, institutional policies and statements, and discussions regarding the proper use of AI within society. Little is made of what AI literacy looks like within the context of specific disciplines. Although students may learn about the flaws of AI and how it can hallucinate, or produce incorrect information, they still struggle to recognize flawed SQL queries, weak relational structures, or misleading outputs inside a database assignment.

One thing that became increasingly noticeable in technical coursework was how quickly students turned to AI systems for complete solutions once those systems became widely available. In SQL assignments, students could often generate entire blocks of code with only a short prompt. Sometimes the generated SQL worked correctly. Sometimes it looked correct but failed once executed in PhpMyAdmin. In other cases, the AI-generated tables ignored relational constraints entirely or produced JOIN statements that did not function as intended. Students who already understood relational databases could usually identify and fix those issues. Students with weaker conceptual understanding often accepted the generated output at face value. That distinction became important because it suggested that the central instructional issue was not simply whether AI was being used, but whether students retained enough disciplinary understanding to evaluate what the AI system produced (Luckin, 2025; Popenici & Kerr, 2017).

The instructional approach described in this paper emerged from redesign work within an undergraduate web development course focused on relational databases and Structured Query Language (SQL). Earlier versions of the assignment required students to manually create tables and write SQL statements independently. Once AI tools became available, instead of having students use them to replace the foundational tasks, an AI activity was created that builds on those foundational steps. Students complete tasks, document prompts that were used, execute the resulting SQL statements, identify why some failed and recursively refine the resulting SQL until optimal results are achieved based on relational database principles. While verification was supposed to happen after the assignment was submitted, it was actually one of the most valuable parts of the assignment. Students quickly discovered that plausible-looking AI-generated SQL often still contained structural or logical problems. Similar instructional concerns involving AI-supported learning and structured assignment integration have also been discussed in recent work examining AI literacy within technical coursework (Glotzbach, 2026).

While there is great value in fostering AI literacy, it is generally more meaningful when incorporated into coursework and discipline-specific instruction, rather than as an add-on skill. Using the redesigned SQL assignment as a concrete example, the discussion examines how structured assignment design can integrate AI into existing coursework while preserving disciplinary rigor. Particular attention is given to scaffolding, verification, prompt documentation, and productive struggle as instructional design principles that help keep conceptual understanding central to the assignment. As generative AI continues to influence higher education, the role of instructional design may become less about restricting AI use and more about structuring how students interact with these systems during learning.

2. AI literacy as an instructional design problem

One of the difficulties instructors currently face is a gap between how AI literacy is conceptualized and how it can be taught to students in higher education. While many workshops and conferences about AI literacy focus on concepts and policy, students are rarely given disciplinary-based assignments that make these concepts relevant. Awareness of issues such as ethics, bias, hallucinations, and responsible use are important for students to possess, but unless and until they are given the opportunity to practice critical thinking about these issues in the context of meaningful work, they will have little idea how to apply what they have learned. This disconnect suggests that AI literacy cannot be fully developed through isolated instruction alone. It must be situated within disciplinary practice where students are required to make decisions, evaluate outputs, and justify revisions using domain-specific knowledge (Ng et al., 2021; Zawacki-Richter et al., 2019).

This issue became increasingly visible in technical coursework where students had access to AI systems capable of producing complete programming solutions with minimal prompting. In database assignments involving SQL, students could quickly obtain functional CREATE, INSERT, SELECT, UPDATE, and DELETE statements without necessarily understanding why those statements worked or failed. In some cases, the generated code appeared correct on the surface but violated basic relational principles or produced unintended outcomes once executed in the database environment. Students who lacked foundational understanding often struggled to recognize those problems. The concern was therefore not simply whether students were using AI, but whether they retained enough disciplinary understanding to evaluate what the AI system produced. Similar concerns have emerged in broader discussions of

AI-supported learning environments, particularly regarding how AI systems may influence student autonomy, reasoning, and decision-making processes (Popenici & Kerr, 2017).

From an instructional design perspective, this creates a problem that extends beyond academic integrity. Most academic assignments are designed with the assumption that, in order to complete them, students will go through a cognitive process involving the information and skills taught in class. However, conversational generative AI models change this equation, as it is now possible to complete academic assignments that test skills and knowledge by simply asking a computer to produce the work. What is seen, for example a completed assignment, may not reflect what has been learned. And this is particularly troubling in technical disciplines, where simple errors in logic, syntax, or structure can have unapparent yet serious consequences. As AI grows in complexity, the way that AI is taught must evolve as well; moving beyond a simple focus on results and towards an emphasis on the underlying reasoning code that produces those results (Holmes et al., 2019; Luckin, 2025).

The redesign described in this paper emerged from the recognition that simply prohibiting AI use would not solve the larger instructional issue. This assignment redesign tackles the more fundamental pedagogical problem. Students are already using these tools outside of the classroom, experimenting with how to incorporate them into their work. Instead of ignoring or banning what students are doing with AI in their free time, this redesign brings the activity into the open and teaches students to use the technology intentionally while challenging them to utilize it appropriately and reflect on the distinctions between AI generated content and human content. Similar arguments have emerged in recent scholarship suggesting that AI integration requires movement beyond purely prohibition-based approaches toward models that emphasize ethical and intentional engagement with AI systems (Eaton, 2023). After executing their queries, students had to evaluate the results for correctness. They also had to critically evaluate and correct any incorrect SQL and justify their decisions. Students demonstrated both AI literacy and disciplinary reasoning.

This strategy for incorporating AI into the SQL assignment started from well-established educational practices for scaffolding and productive struggle. Students first complete a set of foundational tasks learning key relational database concepts. Then, students review, test and modify generated SQL statements, identifying errors and tuning the language used in the prompts to produce more complete and accurate AI code. Many of the most productive learning opportunities occur when the generated code fails to execute correctly. Students must then rely on their understanding of database concepts and query structure to identify the problem and correct it. Productive struggle remains part of the learning process even when AI is involved (Kapur, 2008; Merrill, 2002).

Viewing AI literacy as an instructional design problem rather than simply a technology problem changes how curriculum integration is approached. The emphasis shifts from teaching students about AI in the abstract to designing assignments that require meaningful interaction with AI systems inside disciplinary practice. In this framework, prompting, verification, revision, and reflection become embedded learning activities rather than supplemental skills. The assignment itself becomes the mechanism through which students develop AI literacy while continuing to build disciplinary competence.

3. Structured assignment integration

The assignment used in this redesign is part of an undergraduate web development course in which students learn foundational relational database concepts and Structured Query Language (SQL). Prior to the redesign, the assignment focused entirely on manual database construction and manipulation. Students created relational tables, inserted records, and wrote SELECT, UPDATE, and DELETE statements directly in PhpMyAdmin. The assignment was intentionally procedural. Students needed to understand how primary keys functioned, how relationships between tables were established, and how improperly scoped queries could affect stored data. Those foundational concepts remain central to the course and were not removed during the redesign process.

To incorporate AI-assisted work in this assignment, a third component was introduced to the current workflow; however, this component did not supersede the existing workflow. The traditional workflow of creating tables, filling them with data and manually performing a series of SQL commands to extract specific information to answer academic generated questions remained the same as the first two components of the assignment and were to be completed prior to the introduction of the additional component and the utilization of generative AI tools. The newly introduced component consequently expanded on the traditional workflow rather than substituting it. The problem of using AI to look up answers before demonstrating basic competence with a particular skill was avoided by moving the use of AI to after students had shown some grasp of a skill. Using AI this way allowed them to continue developing and refining their skills (Merrill, 2002).

In the third component of the assignment, students prompt an AI system to design an additional relational database table that meaningfully connects to the schema they previously created. The assignment requires students to specify constraints directly in their prompts, including primary keys, appropriate data types, and at least one foreign key relationship when relational connections are present. Students then prompt the AI system to generate SQL statements for creating the table and manipulating data through INSERT, UPDATE, DELETE, and SELECT operations. At least one relational JOIN statement must also be included when appropriate. Rather than treating the AI-generated SQL as a completed solution, students are required to execute each statement within PhpMyAdmin and verify that the queries function correctly within the actual database environment.

The verification step ended up changing the assignment more than expected. Students had to verify not only their own work, but also the SQL code generated by an artificial intelligence program for a variety of tables. Although the code looked good to the students, upon copying and pasting the code into PhpMyAdmin, a number of errors were encountered including relational errors, syntax errors and missing constraints. In some cases, the tables generated by the AI for tables that were meant to have a primary key, failed to declare a primary key. Other code had field definitions that were defined incorrectly within the overall schema. Students learned that simply copying and pasting from the AI program is not good enough in these assignments. The students are forced to understand the AI generated code, process it internally, find errors and correct them, all the while drawing upon prior knowledge of relational databases. This is the most instructionally valuable part of the assignment.

A second key aspect of this assignment is the documentation of the actual prompts written to the AI model, the resulting SQL code generated by the AI model, and the resulting final corrected and executable SQL code provides valuable insight into both the AI's process and the results of using it, as well as how prompting affects technical communication outcomes in terms of quality and organization. Well-structured prompts resulted in high quality, organized SQL code that adhered to relational database design principles.

The redesign also preserves disciplinary rigor by maintaining traditional evaluation standards. Students are not graded on whether they used AI effectively in a general sense. Instead, grading remains grounded in SQL competency and relational database accuracy. Queries must execute correctly, constraints must function properly, and relational integrity must be maintained throughout the schema. AI use does not exempt students from understanding the consequences of poorly scoped UPDATE statements or improperly defined keys. The database environment itself becomes a form of verification because MySQL either accepts or rejects the generated code based on structural validity. As a result, AI functions less as an authority and more as a drafting partner whose outputs require continual evaluation.

Embedding AI within the assignment in this structured way changes the instructional role of the technology. Rather than operating outside the learning process, AI becomes integrated into disciplinary practice under clearly defined constraints. Students engage with AI-generated code while still remaining responsible for verification, revision, and conceptual understanding. The assignment therefore treats AI literacy not as a separate competency, but as something developed through direct interaction with AI systems inside authentic technical coursework.

4. Implications for curriculum design

Rather than simply engaging in policy discussions, curriculum redesign can introduce students to AI in ways that afford deeper and nuanced engagement with the technology through activities specific to their major discipline. In this paper, we describe how a course activity was redesigned to address these goals and how engagement with AI within a design activity afforded students' use of AI in relation to their major discipline. Specifically, students in the redesigned activity engaged in design, testing, revising, and evaluating as they utilized AI tools. This integration helps preserve the connection between AI literacy and disciplinary thinking.

As students incorporate AI into their assignments, it is likely that the manner in which they utilize the technology will be shaped by the design of the assignment rather than by the features of the technology itself. In order to ensure that students utilizing AI remain engaged in disciplinary concepts and processes, it is crucial for instructors to design assignments that demand documentation of prompts, verification of reliability, repeated regeneration of content, and explanation of processes. While typical discussions about tools center on their rapid evolution, a more fruitful conversation might focus on how those tools are used, and the design principles (scaffolding, transparency, and productive struggle) that guide their use. (Kapur, 2008; Merrill, 2002).

The redesign also offers a practical model for faculty adoption. Many instructors remain hesitant to integrate AI into coursework because they perceive the process as requiring major curriculum redesign or entirely new course structures. This assignment demonstrates a more incremental approach. The foundational assignment remained largely intact while AI interaction was added through a structured extension activity. Existing learning objectives were preserved, and traditional disciplinary expectations continued to guide evaluation. Similar instructional approaches involving structured AI integration within technical coursework have also been explored in related work focused on AI literacy and assignment design (Glotzbach, 2026). For faculty members seeking manageable entry points into AI integration, modifying existing assignments may be more sustainable than large-scale curricular replacement.

Finally, this approach reinforces the idea that AI literacy is inseparable from disciplinary judgment. In the SQL assignment, students do not simply learn how to prompt an AI system. They learn how to evaluate relational structures, identify flawed outputs, and reconcile generated code with actual database behavior. The disciplinary concepts remain central throughout the interaction. This distinction is important because AI literacy risks becoming superficial when disconnected from authentic disciplinary practice. Embedding AI literacy into curriculum through structured assignment design helps ensure that students continue to develop the reasoning, verification, and evaluative skills necessary for meaningful learning in AI-supported environments.

5. Conclusion

Generative and agentic AI systems are increasingly influencing how students approach academic work, creating new challenges for instructional design in higher education. This paper argued that AI literacy should not be treated as a separate or supplemental competency, but instead embedded directly within disciplinary coursework through structured assignment design. Using a redesigned SQL assignment as a concrete example, the discussion illustrated how AI can be integrated into existing coursework while preserving disciplinary rigor and meaningful engagement with core concepts.

The assignment redesign positioned AI as a drafting and extension tool rather than a replacement for learning. Through sequencing, verification, prompt documentation, and revision, students remained responsible for evaluating and correcting AI-generated outputs using disciplinary knowledge. In this model, instructional design determines whether AI interaction supports conceptual understanding or substitutes for it. As AI systems continue to evolve, the challenge for educators will not simply be whether these tools are allowed in coursework, but how learning environments are designed around their use. Embedding AI literacy within authentic disciplinary practice offers one practical pathway forward for integrating emerging technologies while preserving the intellectual goals of higher education.

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INVESTIGATING CONTRADICTIONS REGARDING EDUCATION FOR SUSTAINABLE DEVELOPMENT INTEGRATION AMONG ACADEMICS: AN INTERDISCIPLINARY PERSPECTIVE

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Abstract

Education for Sustainable Development (ESD) is recognised as a key approach for addressing complex global challenges through higher education, yet its integration remains uneven across disciplines. A significant barrier concerns tensions surrounding roles and responsibilities for ESD integration, often resulting in fragmented practices. This study explores contradictions emerging in interdisciplinary academics' perspectives regarding ESD integration through authentic conversations in a collaborative Community of Practice. Guided by the research question, *what contradictions emerge in interdisciplinary academics' perspectives regarding the integration of Education for Sustainable Development,* the study draws on Cultural-Historical Activity Theory (CHAT). Focusing on primary-level contradictions within the division of labour, the findings reveal competing assumptions about whether ESD is discipline-specific or a shared responsibility. These tensions are intensified by limited policy visibility and institutional support. The study argues that making such contradictions visible through authentic conversations is essential for coherent and intentional ESD integration.

Keywords: *ESD, CHAT, division of labour, interdisciplinary collaboration.*

1. Introduction

Education for Sustainable Development (ESD) is promoted internationally as a transformative approach aimed at equipping learners with the skills, knowledge, attitudes, values, and competencies required to address challenges such as climate change, inequality, and social injustice (UNESCO, 2017). Within higher education, ESD integration calls for interdisciplinary approaches that transcend traditional subject boundaries. However, research shows that ESD integration within university curricula remains fragmented and inconsistent (Fiselier, Longhurst & Gough, 2018).

In South African teacher education, this challenge is intensified by disciplinary silos, prescriptive curricula, and limited policy guidance on ESD. Academics often engage with sustainability-related ideas, but such engagement is typically implicit, uncoordinated, and reliant on individual initiative rather than institutional coherence (Kazeni & Nyamupangedengu, 2025; Mandikonza & Kavai, 2023).

This paper reports on a study that emerged from concerns raised within an academic Community of Practice regarding who is responsible for integrating ESD, how it should be enacted across disciplines, and whether such integration should be explicit or embedded within existing pedagogical practices. Using authentic conversations as a professional learning strategy (Swain & Spire, 2020), the study investigates how academics from science, mathematics and social sciences teacher education negotiate their understanding of ESD and their roles in its integration.

The study was guided by the research question:

What contradictions emerge in interdisciplinary academics' perspectives regarding the integration of Education for Sustainable Development?

By applying Cultural Historical Activity Theory (CHAT) as an analytical lens, the paper foregrounds contradictions, particularly those related to the division of labour as sources of tension, but also as potential catalysts for expansive learning and pedagogical transformation (Sannino & Engeström, 2018).

2. Methodology

2.1. Research design

This qualitative interpretive study used authentic conversations within an interdisciplinary Community of Practice involving teacher educators from Life Sciences, Physical Sciences, Mathematics and Social Sciences.

2.2. Participants and context

Participants were teacher educators from Life Sciences, Physical Sciences, Mathematics and Social Sciences. Conversations were facilitated in a collegial, non-hierarchical environment. The study was situated in a teacher education context where academics prepare pre-service teachers across multiple subject areas, highlighting the strategic importance of teacher education in advancing ESD integration.

2.3. Data generation

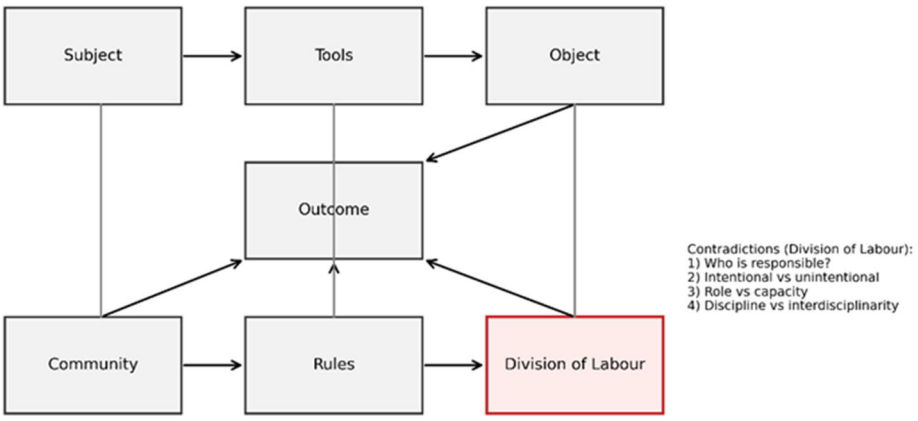
Two two-hour authentic conversation sessions were conducted. Discussions focused on participants' understandings of ESD, roles and responsibilities for integration, current teaching practices, perceived challenges and institutional constraints. Conversations were audio recorded and transcribed verbatim.

2.4. Data analysis

Data were analysed thematically using CHAT. The analysis focused on identifying primary-level contradictions, particularly those clustered around the division of labour within the ESD integration activity system.

2.4.1. Explanation of how CHAT was used to analyse data. Figure 1 below based on Engeström's model of an activity system, which consists of seven interconnected components: **subject, tools, object, rules, community, division of Labour**, and **outcome** represent the CHAT activity system for ESD integration, with the Division of Labour highlighted in red and annotated with the principal contradictions identified in the authentic conversations.

Figure 1. Adapted from Engeström's model of an activity system.



At the top of the diagram, the subject refers to the lecturers involved in teaching across different disciplines namely Life Sciences, Physical Sciences, Mathematics, Geography, History and Methodology. These lecturers attempt to integrate ESD into their practice by acting upon the object, which in this study is the collective goal of achieving intentional, effective and interdisciplinary ESD integration across teacher education programmes. The transformation of the object is mediated by tools, which include pedagogical strategies (e.g., case studies, scenarios, simulations), curriculum documents (e.g., CAPS), conceptual resources (e.g., SDGs, sustainability competencies), and subject-specific examples used in teaching.

Beneath the components subject, object and tools, the community encompasses all individuals and groups with a shared stake in the object of the activity. This includes lecturers across all disciplinary divisions, students, departmental structures, the wider School of Education, and policy-setting bodies that influence ESD expectations. The rules component refers to both formal and informal regulations, norms, expectations and constraints that guide lecturer behaviour. These include institutional policies, curriculum prescriptions, disciplinary norms, and broader global agendas like SDG 4.7.

The division of labour, highlighted in red in the diagram, was the central focus of our analysis. This component describes how roles, responsibilities, tasks and authority are distributed among lecturers and programmes. Finally, in the middle of the diagram, the outcome represents the intended result of the activity system namely, coherent, intentional and interdisciplinary ESD integration that enhances the quality of teacher education.

3. Results

In this paper, we foreground tensions clustered in the division of labour, leading to fragmented, inconsistent integration across disciplines. These tensions/contradictions were about: Whose responsibility ESD is, what counts as ESD in practice, whether lecturers are integrating it intentionally or unintentionally, what constitutes "adequate" integration, different understandings of ESD across disciplines and lack of alignment between policy, institutional expectations, and practice.

The contradictions show that there is a complex set of relationships that shape how lecturers at the teacher education institution engage in the activity of integrating ESD into their teaching. In addition, the division of labour is where primary contradictions emerged from most during authentic conversations. Table 1 below shows a summary of these contradictions as well as CHAT elements, evidence and implications.

Table 1.

Summary Table 1. Contradiction → CHAT Element(s) → Evidence → Implication.

Contradiction	CHAT Element(s)	Evidence (Transcript)	Implication for ESD Integration
1) Who is responsible for ESD?	Division of Labour (+ interactions with Tools/Rules/ Community)	"To me… it's more of a science topic than a mathematics topic." (Prof. Marks) "ESD is for everyone… every subject should develop critical thinking." (Prof. Yuna)	Ambiguity in role allocation generates fragmentation and abdication (not my subject), directly mirroring the abstract's claim that responsibility tensions slow integration.
2) Intentional vs unintentional integration	Division of Labour (+ interactions with Tools/Rules/Community)	"We incorporate some principles..but unintentionally." (Dr Naomi) "People may have been integrating ESD and not know it." (Dr Uje)	Confusion over whether implicit practices "count" produces inconsistent standards of adequate integration and unclear expectations of labour.
3) Role expectations vs capacity/ knowledge	Division of Labour (+ interactions with Tools/Rules/ Community)	"Only one really understood what ESD was… nobody ever mentioned it." (Dr Naomi) "Policy does not mention ESD… we don't have liberty to incorporate it." (Dr Naomi; Dr P)	When role expectations outstrip tools and rules (knowledge, policy), contradictions intensify, producing hesitation and uneven practice.
4) Discipline identity vs interdisciplinary expectations	Division of Labour (+ interactions with Tools/Rules/ Community)	"We look in cells—we do not know what the next person is doing." (Dr Naomi) "Maths is the language of science… modelling, numbers." (Prof Marks;	Tension between strong disciplinary identities and interdisciplinary labour fuels uncertainty about who does what, where, and when.
5) Teaching tasks vs ESD outcomes	Division of Labour (+ interactions with Tools/Rules/ Community)	"If I teach this concept, how do I teach sustainable development?" (Dr Uje) "We cannot claim behavioural outcomes we have not seen." (Naomi)	Unclear mapping between tasks and ESD competencies causes role confusion in planning, enactment and assessment.
6) Prescribed curriculum vs ESD flexibility	Division of Labour (+ interactions with Tools/Rules/ Community)	"We have a prescription… we don't have the liberty to incorporate it." (Dr Naomi) Desire for field trips but lack of resources (Dr Noah).	Responsibility without authority/resources is a classic division-of-labour contradiction, producing workarounds and inconsistency.
7) Collaboration expected vs structures absent	Division of Labour (+ interactions with Tools/Rules/ Community)	"We need to sit together… so that we actually do something." (Dr Casper) "We do not know what the next person is doing." (Dr Naomi)	Authentic conversations temporarily substitute for missing structures, but sustained collaboration needs formalised roles and routines.
8) Definitions contested → labour contested	Division of Labour (+ interactions with Tools/Rules/ Community)	"ESD is education… focus on quality education." (Dr C) "Sustainable development is subject-specific" vs "for everyone." (agreed on)	When meaning is unsettled, the division of labour is unsettled; shared definitions are a precondition for coherent role allocation.

4. Discussion of findings

Using CHAT, the findings show that contradictions across activity system components shape academics' engagement with ESD integration. The division of labour emerged as the primary site of contradiction, closely interacting with rules, tools and community expectations. These contradictions and the misalignments which resulted in uneven and inconsistent integration across disciplines are discussed below.

4.1. Who is responsible for ESD?

Participants expressed divergent views regarding responsibility for ESD integration. Some positioned ESD within science-related disciplines, while others asserted that all disciplines share responsibility. This lack of consensus resulted in uncertainty and fragmented role allocation. This contradiction confirms what Abrahams and Van Wyk (2024) observed in their study, that ESD implementation is sporadic, with many 'mainstream' disciplines (engineering, mathematics) shifting responsibility to "development studies" or education departments. These responsibility tensions are likely to slow integration.

4.2. Intentional vs unintentional integration

Lecturers reported integrating ESD implicitly through examples and discussions without explicitly naming it, while others argued for intentional and planned integration. Munasi (2024), in their study of grade 11 learners, found out that unintentional and unplanned ESD integration, though it may raise awareness, the inconsistence often leaves gaps in student understanding of ESD.

4.3. Role expectations vs capacity/knowledge

Participants highlighted limited conceptual understanding of ESD and minimal professional development opportunities. Expectations to integrate ESD without adequate conceptual or policy support intensified contradictions within academic roles. This showed that contradictions are likely to intensify when role expectations outstrip tools and rules (knowledge, policy), producing hesitation, lack of confidence and uneven practice.

4.4. Discipline identity vs interdisciplinary expectations

Strong disciplinary identities influenced how academics perceived their responsibilities. These identities often conflicted with expectations for interdisciplinary collaboration, contributing to uncertainty about shared responsibility. Tension between strong disciplinary identities and interdisciplinary labour which can fuel uncertainty about who does what, where, and when, Abrahams & Van Wyk (2024).

4.5. Teaching tasks vs ESD outcomes

Participants questioned how routine teaching tasks align with ESD outcomes. For example:

Unclear links between disciplinary content and ESD competencies complicated planning, enactment and assessment. This implies that while ESD competencies are well-defined, their integration into disciplinary content remains unclear and inconsistent. Hence the need for stronger conceptual models, assessment tools, and cross-disciplinary accountability to bridge this gap.

4.6. Prescribed curriculum vs ESD flexibility

Rigid curriculum prescriptions and limited resources constrained lecturers' ability to integrate ESD meaningfully. This contradiction also intensifies the tension of expected striving to fulfil roles and responsibilities but without authority and/or resources to do so, making it unattainable to adequately integrate ESD.

4.7. Collaboration expected but structures absent

While interdisciplinary collaboration was widely valued, participants reported a lack of institutional structures, time and policy support. Authentic conversations provided an initial platform but could not substitute for sustained structural support which is encouraged by Berg and Vester (2023).

4.8. Definitions and labour are contested

Competing conceptualisations of ESD resulted in contested interpretations of who should integrate it and how. Without shared meaning, coherent division of labour remained difficult to achieve. For example Dr Casper insisted that *ESD is education… focus on quality education,* yet four of the participants (Prof Marks, Drs Hillary, Muponi, Naomi and Noah) thought sustainable development is subject-specific vs the

other three (Prof Yuna, Drs Casper and Uje) who were of the idea that ESD is for everyone. Without a common understanding of ESD conceptualisations, the tension remains unresolved.

5. Conclusion

Through our authentic conversations, we were enlightened that ESD integration is not a simple matter of changing teaching techniques but rather, a systemic activity influenced by interacting elements. The contradictions that we highlighted in the division of labour reveal why lecturers experience uncertainty, uneven practice, and disciplinary tensions. The authentic conversations made the tensions visible and enabled us to provide a theoretical explanation that supports our argument that structured, cross-disciplinary dialogue is essential for resolving contradictions and moving toward a shared ESD framework.

6. Recommendations

Taking into consideration the findings, the following recommendations should be considered: Develop a shared ESD Framework: Institutions should co-develop a flexible, interdisciplinary framework that clarifies what counts as ESD integration across disciplines. Institutionalise Authentic Conversations: Regular, structured dialogic spaces should be embedded within professional development to support collective sense making and learning. Enhance Policy Visibility: ESD should be explicitly articulated in institutional policies, curriculum guidelines, and quality assurance processes. Support Intentional Pedagogy: Academics should be supported to make ESD integration intentional, including assessment strategies that acknowledge cognitive, socio emotional, and behavioural domains.

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BETWEEN PROTOTYPES PROJECTS AND CREATIVE PROCESSES - EDUCATIONAL ROBOTICS TAKES SHAPE THROUGH THE MAKER CHALLENGE

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Abstract

The integration of Maker Culture and Educational Robotics emerges as a promising pedagogical approach for reshaping teaching practices, shifting the student from a passive consumer to an author and protagonist of their own learning process. The activities developed are primarily aimed at Basic Education teachers and university interns who act as supporters and multipliers of the project, playing a strategic role in technological mediation, peer training, and the sustainability of maker practices in schools. The project starts with the analysis of real problems in the school community and its surroundings, giving social meaning and relevance to the technological solutions developed by the students. The methodology adopted follows the Problem-Based Learning (PBL) model, articulated with Project-Based Learning, so that each maker challenge originates from a concrete problem situation, investigated and transformed into an opportunity for creative intervention through prototyping and automation. The analyzes are predominantly based on Seymour Papert's (1980) constructionism, for whom meaningful learning stems from the construction of shareable artifacts, and on Mitchel Resnick's (2017) perspective on creative learning, structured around projects, peers, and playfulness. Contemporary authors, such as Paulo Blikstein (2013, 2020) and Leo Burd (2016), expand this framework by associating Maker Culture with technological democratization, educational equity, and the development of computational thinking. The methodological structure is organized as a Maker Challenge, comprising: awareness-raising and participatory diagnosis, collaborative ideation, solution planning, prototyping with recyclable materials and open platforms such as Arduino, programming, iterative testing, and socialization of results. The activities are distributed into categories—automata, creative circuits, motorization, programming with Scratch, and automation with sensors—always guided by the appreciation of the investigative and construction process. The assessment, of a formative and continuous nature, prioritizes reflective records, peer collaboration, creativity, and the ability to iterate solutions. It is concluded that the articulation in the project between maker activities and educational robotics constitutes a fertile ecosystem for pedagogical innovation, fostering critical thinking and strengthening links between technology, sustainability, and social participation, especially when mediated by educators committed to authorship and equity.

Keywords: *Maker culture, educational robotics, creative learning, problem-based learning, constructionism.*

1. Introduction

The growing presence of digital technologies in contemporary society imposes on schools the challenge of redefining their pedagogical practices, overcoming transmission models and incorporating approaches centered on authorship and experimentation. This imperative intensifies in institutions that serve working-class populations, contexts in which access to technologies is not distributed equitably among students. In this scenario, the articulation between maker activities and educational robotics emerges as a powerful formative strategy, promoting technological creation experiences guided by the resolution of real problems. Far from technocratic or merely instrumental perspectives, this integration constitutes a space for investigation, imagination, and materialization of ideas, in which error is an inherent component of the process, collaborative work is systematically encouraged, and learning develops in a situated and meaningful way.

It is hoped that this will contribute to the debate about pedagogical strategies capable of bringing the school closer to the languages and logics that structure the contemporary technological world, without losing sight of the principles of equity, collaboration, and critical thinking that should guide all transformative educational practices.

In parallel, the research seeks to encourage scientific initiation and the implementation of structured technological activities, enabling students to act as active subjects in the construction of their own knowledge. In this context, the practice of robotics aims to provide opportunities for the development of fundamental cognitive and socio-emotional skills, with an emphasis on logical reasoning, creativity, autonomy, and student leadership. Ultimately, by enabling such experiences, the project intends to consolidate an environment of multiple learning experiences, in which practical and technical work serves as support for the exercise of critical, reflective, and transformative thinking in the face of contemporary technological reality.

2. Literature review and theoretical framework

Maker culture, consolidated as a socio-technical movement founded on the principles of *Do It Yourself* (DIY) and *Do It With. According to Dougherty* (2012), the democratization of the means of technological production represents a shift from exclusively occupying the role of consumers to becoming active producers of technology. In this perspective, Blikstein (2013, 2020) advocates for *makerspaces* as laboratories of educational innovation—environments where students learn science and engineering through invention—while Burd (2016) emphasizes the inclusive potential of this culture, especially in contexts of social vulnerability, by enabling critical and creative access to technologies. Learning based on hands-on experimentation is, therefore, a structuring element of this movement, fostering cognitive engagement, creativity, and autonomy in formative processes.

In the field of educational robotics, the theoretical foundations are rooted in Seymour Papert 's (1980) constructionism, which posits that learning occurs more meaningfully when the subject constructs shareable artifacts—programming, assembling, and testing prototypes thus becomes a way of thinking about their own knowledge. Resnick (2017) expands on this view by proposing creative learning structured around the four Ps : *Projects* , *Passion* , *Peers* , and *Play* , reaffirming that robotics projects allow students to develop ideas with personal meaning, collaboratively and playfully. Open platforms in education, such as Arduino, reduce technical and economic barriers, favoring the understanding of real-world projects.

Computational thinking, defined by Wing (2006) as a set of skills involving problem decomposition, pattern recognition, abstraction, and algorithm creation, is articulated within this set of perspectives. In maker robotics, such skills emerge from concrete and contextualized situations—activating a motor, automating lighting systems, or developing environmental sensors—demonstrating that technological learning does not depend exclusively on sophisticated equipment, but, above all, on pedagogical intentionality and a clearly delineated formative project.

Given this theoretical landscape and the contemporary demands for more active and meaningful educational practices, this article aims to analyze the theoretical and methodological foundations of the integration between maker culture and educational robotics, as well as to propose a practical activity structured in the form of a maker challenge , with an emphasis on prototyping processes with accessible materials and open platforms, transforming traditional classrooms into technological creation spaces (" *makerspaces* ").

3. Objective

The Maker Challenge is an offshoot of the Educational Robotics Project, developed since 2015 in the Niterói Municipal Education Network. It is an essentially interdisciplinary proposal whose general objective is to foster integration between the various areas of knowledge that make up the curriculum, providing students with a comprehensive experience in building prototypes and functional physical models. In developing this research, specific objectives are outlined that primarily aim to identify and map teachers with a scientific vocation, in order to establish a network of multipliers capable of disseminating the methodology in the school environment.

4. Projects and methods

The Interns Project provides the necessary support to school teachers in all work done with technology. The interns, future teachers in different areas of knowledge—such as Mathematics, Portuguese Language, among others—are trained by the pedagogical team of the Municipal Department of Education (SME), responsible for assisting in the use of technology in daily school life and for conducting training workshops. This training team is composed of specialists, masters, and doctors with experience in educational technology. The teachers participated in two workshops, on different days, with the SME team providing assistance in the schools when necessary, with the aim of supporting the activities developed in the schools.

Workshop Stages and Procedures:

A. Awareness and Problem-Solving: Discussion about everyday school or community problems—such as energy waste, flooding, and accessibility—and their possible solutions. The group of teachers collectively selects a problem to be analyzed and discusses possible solutions. Starting with the second workshop, this phase also includes sharing the progress and difficulties observed in practice with the students.

B. Workshop Ideation: The group is divided into five categories, with no restrictions on the number of participants. The SME team leads the workshop, and the groups define the technological solution—preferably automated—that represents the answer to the identified problem, according to the following categories:
   - Category 1 — Automata: Machines with mechanical movement, usually operated by a crank, that imitate the movement of living bodies.
   - Maker Experimentation with Simple Electrical Circuits: Assembling prototypes with low-cost materials, such as LEDs, aluminum foil, modeling clay, and reusable materials.
   - Category 3 — Motorization: Activities with simple circuits and motors, and prototypes built with reusable or low-cost materials.
   - Category 4 — Programming/Scratch: Programming activities and representation of solutions using the Scratch environment.
   - Category 5 — Automation: Prototyping with Arduino interface, an electronic prototyping platform that enables automated control of prototypes.

   Note: These categorizations allow teachers to develop projects suitable for different educational levels, with each group able to select one or more categories according to the level of their students.

C. Prototype Design: Creating sketches, defining materials, and specifying how the device will function.

D. Maker Construction, Circuit Assembly and Programming: Structural assembly with low-cost and recyclable materials; insertion of LEDs, motors and sensors; and coding in blocks or simplified language associated with Arduino, with a view to automating prototypes.

E. Testing and Iterations: Construction of a model representing the solutions developed by the different groups.

F. Socialization and Culmination: Teachers adapt the workshops to the reality of their classes and pedagogical projects for application in schools, preferably with the help of other teachers from the school. The culmination occurs with the presentation of the activities carried out by all participating school units.

5. Assessment

The evaluation of maker activities and educational robotics moves away from the traditional metric based on the "right or wrong" dichotomy to consolidate itself as a process- oriented and formative monitoring, in which learning is understood as a continuous flow, and not as a static result. In this paradigm, the centrality of the educational process relegates the final product to a secondary role, privileging the investigative path taken by the student.

The analysis begins with observing participation and collaboration, evaluating how the student interacts with the group, shares knowledge, and manages collective dynamics in problem-solving. Creativity in solutions is observed not only through aesthetic originality but also through the ability to apply limited resources innovatively to overcome technical challenges. Fundamentally, the capacity to test and iterate—the essence of engineering thinking and the maker approach —is valued, where error is not penalized but treated as valuable data for the continuous improvement of the prototype.

To document this evolution, procedural documentation becomes an indispensable tool, functioning as a portfolio of evidence that demonstrates the hypotheses raised and the paths discarded throughout the project. Finally, the evaluation culminates in the argumentation during the presentation of the models developed by all the schools. This is the moment when the student must be able to logically articulate their choices and defend the decisions made throughout the process. Therefore, the focus is on building critical thinking and student autonomy, ensuring that effective learning is anchored in lived experience, and not just in the final product created.

6. Discussion

Implementing maker -based projects in an educational environment demands a shift in perspective, where the pedagogical focus moves from the final product to the investigative journey and the development of the student's self-awareness. In this process, teacher mediation should foster moments of reflective pause, in which teachers and students are encouraged to analyze their own actions. This process begins with a critical analysis of the technical and conceptual obstacles encountered during prototyping, transforming error into an indispensable didactic variable for understanding the complexity of the object of study. By debating the strategies used to solve problems, the groups develop not only cognitive skills but also socio- emotional skills linked to resilience and horizontal collaboration.

Figure 1. The three images refer to the culmination event with all the schools participating in the Maker Challenge. In the first image on the left, a teacher makes adjustments to the program that automates the model; to the right of this image, two students explain a game they built; subsequently, one of the trainers displays the model produced by teachers during the workshops.

The practice of iteration—the act of testing, evaluating, and modifying—becomes the central axis of learning, leading teachers and students to design changes and refinements to the original prototype as an exercise in design thinking. Beyond technical mastery, the pedagogical journey seeks to contextualize knowledge, prompting students to perceive the socio- environmental impacts of their creations. Thus, by reflecting on the applicability of the solution in the community and the ethical commitment between technology and sustainability, learning transcends the instrumental dimension and reaches a critical-reflective sphere. The academic path of educational robotics is validated by the student's ability to document their progress, argue their choices, and recognize themselves as a subject capable of transforming reality through conscious innovation.

7. Conclusions

The integration of maker activities and educational robotics proves to be a powerful strategy for reshaping pedagogical practices, shifting the student from the position of technological consumer to that of solution creator. By emphasizing projects, prototyping, and experimentation—practices that promote meaningful, interdisciplinary, and socially contextualized learning—it is observed that the combined use of low-cost materials and open-source electronic prototyping platforms broadens access and strengthens educational equity. The exchange of experiences among teachers of different specialties and from different segments of Basic Education proves to be particularly enriching for the consolidation of a collaborative pedagogical culture.

It is concluded that maker projects in educational robotics constitute formative ecosystems capable of developing computational thinking, creativity, and student leadership, contributing to an education aligned with contemporary demands without abandoning its humanizing commitment.

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"LIFE IS YOUR BLOCK OF CLAY." APPLYING A TYPOLOGY FOR LEARNING IN MAKERSPACES

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Abstract

This paper contributes to identifying the often-implicit learning that minoritized youth do in community-based making in makerspaces and afterschool programs. We apply Tomko and colleagues' (2023) typology for learning in makerspaces to artifact elicitation transcripts from two projects that integrated math/STEM and making with minoritized youth to test its applicability to a younger population and a different setting. The implementation of this typology identifies both how and what individuals learn through making activities and the gaps we find in the framework when applying it to learning in informal spaces. Given that learning through making is often implicit, having the tools to identify it and make it explicit supports the value of learning through making in out-of-school environments for minoritized youth.

Keywords: *Makerspaces, typology for learning, modes of learning, products of learning, artifact elicitation.*

1. Introduction

Tomko et al.'s (2023) Typology for Learning Framework (TLF) is a classification of university students' learning in engineering program makerspaces. Our team applied this framework to the data we collected in two projects via artifact elicitation interviews with participating youth. These two projects integrated community-based math/STEM and making in the United States: AAMASE, with middle and high school Black young women in a makerspace and AMPED4Making, with middle school Latine youth in an afterschool program. In these projects, researchers and community partners co-designed curriculum that integrated math/STEM and making through activities that were culturally relevant and that reflected the youth's interests. Youth designed projects that addressed community problems of their choosing. The projects' research, which informed the iterative development of the curriculum, used artifact elicitation interviews as a key data gathering strategy.

2. Theoretical framework and literature review

Tomko and colleagues' (2023) TLF includes two main categories with their corresponding subcategories: (1) modes of learning (learning by doing, and learning through others/communicating and managing), and (2) products of learning (content knowledge and skills, cultural knowledge and skills, ingenuity, and self-awareness). We applied TLF to the projects' artifact elicitation interview data to test its applicability to middle and high school youth. We consider that this typology can help educators identify the learning that occurs through making as well as support the identification of activities that support those types of learnings.

Artifact elicitation is a data collection method that uses objects make by program youth to center the conversation (Douglas et al., 2015). Participant-generated objects embody the knowledge, skills, and attitudes held by the youth that made them and elicit the motivations and feelings they had when they made them. The youth were excited to share what they made and how they made it. Typical questions included: How did you design this object? What challenges did you face? If you made it again, what would you do differently? This method allowed us to gather data on the youth's making and learning process using a format that worked with the programs' regular flow.

3. Research design and methods

The purpose of this study is to test the applicability of TLF to middle and high school youth and to see how it supports the identification of different types of learning in informal learning spaces that

involve making. In Tomko et al.'s (2023) study, participants were university students in an engineering design class who participated in three 90-minute individual interviews that were spaced out over 3 weeks. In contrast, our participants were middle and high school youth in two out-of-school making programs. We conducted opt-in artifact elicitation interviews once a semester. Many were group interviews of up to 4 youth that lasted 5-10 minutes each (Levin-Güracar et al., 2024).

The study's high school-aged youth attended an eight-week long program comprised of 3-hour sessions weekly in a local makerspace, where they learned from a program facilitator, expert makers, and entrepreneurs (Rafanan et al., 2025). The study's middle school-aged youth attended a ten-week long afterschool program comprised of hour-long weekly sessions at their schools, facilitated by a youth educator (Jaumot-Pascual et al., 2025).

We analyzed six artifact elicitation interviews from three participants: Rose and Pedro, both seventh graders, and Serena, a high school junior. All three participated in at least two artifact elicitation interviews. Initially, they were not used to being interviewed given their ages and the informal setting. However, since they participated in repeated program cycles and were interviewed multiple times, they became familiar with the interviews. The setting and associated lack of formal assessment also contributed to their comfort and reduced their urge to provide socially desirable responses. We used TLF to deductively code the transcripts using its categories and subcategories as our codebook.

4. Findings and discussion: Typologies of learning observed

Although the participants and the setting in Tomko et al.'s (2023) study and ours are different, we found that TLF was generally applicable to both our study participants and settings, supporting the identification of different types of learning. We use the TLF structure to provide examples for many TLF categories and subcategories.

1. Learning by Doing is the discussion of "learning through experiences as a direct result of one's own actions," and includes five subcategories: (1.1) *Failing*, (1.2) *Struggling*, (1.3) *Practicing*, (1.4) *Iterating*, and (1.5) *Exploring* (Tomko et al., 2023, p. 6). We found evidence of participants* talking about making mistakes and iterating. Serena's discussion of her challenges in throwing a cup on the pottery wheel is an example of (1.1) *Failing* and (1.2) *Struggling*. She was able to articulate how she failed and how she tried to solve the issue:

> This one right here [picks up a short light blue ceramic cup]. I had a difficult time with throwing this. ... So, like, you'll see a little hole in it. In the inside, you can see, like, how it has a little hole in it. That's when I was throwing it, and I went down too deep. And we tried to bring it up. It really didn't go up as well. So, it's a little deep hole and then you have a hole on the side.

The following quote by Rose, where she talked about playfully practicing her sewing and using the tools of the craft, is an example of the (1.3) *Practicing* and (1.5) *Exploring* subcategories: "I used to sew when I was younger. I have, like a, like a grid thing to let me practice with it. So, I was just like, sewing on that, just messing with it."

Some *Learning by Doing* subcategories were not as prevalent in our data due to the program's structure, which provided projects to explore different making disciplines but did not include opportunities to iterate failed projects. However, youth were aware of how they would iterate a project if they got a chance, as we see later with Serena's clay project in category (3) *Content and Skills*.

2. Learning through Others/Communicating & Managing is the "discussion of seeing what other people are doing or interacting with other people as a way to beget more understanding of something" (Tomko et al., 2023, p. 6) and includes five subcategories: (2.1) *Observing and Listening*, (2.2) *Collaborating*, (2.3) *Receiving or Soliciting Help or Training*, (2.4) *Giving Help or Instruction*, and (2.5) *Leading, Managing, and Administering*.

Serena's discussion of how her sister helped her while she was making a ceramic heart is an example of subcategory (2.3) *Receiving or Soliciting Help or Training*. She shared, "My [clay] heart didn't work out at first. It's so– My sister told me to just do, like, one side and then do the other side. So, I did that." Though Serena's sister's instructions were simple, they helped her accomplish her goal of making a clay heart.

During our observations of the programs' learning sessions, we often noted participants learning with others and providing instruction to each other. However, these interactions did not tend to appear in the interviews, since youth were used to the program's group-based pedagogical interactions and youth considered collaboration and communication as part of the program's culture, not necessarily part of their learning.

* All participant names are pseudonyms.

3. Content Knowledge and Skills is the "discussion on the knowledge, skills, and technical jargon acquired in various subject areas" (Tomko et al., 2023, p. 6). The subcategories are (3.1) *Design*, (3.2) *Manufacturing and Tools*, (3.3) *Computational Tools*, (3.4) *Materials*, and (3.5) *Components*. This is the category of the TLF for which we have the most examples because it aligns well with the design and maker emphasis in our projects.

In almost every interview, we found evidence of youth talking about the design process, including prototyping, creating, and the reasons for creating and making a design. The following excerpts are examples of the types of conversations that took place in the program around subcategory (3.1) *Design*. Rose, Pedro, and Serena discussed how they ideated their designs for projects that represented their families. Rose explained the steps to build her stuffie by showing how the different parts were integrated to build the whole.

Rose: Okay, this is a stuffie of a muffin.
Interviewer: Of a muffin?
Rose: It's a muffin, yeah. Uh.
Interviewer: Huh. And how did you make it? [To youth who speaks Spanish: ¿Cómo lo hizo?]
Rose: So, we cut from fabric, right? And then we sew part of it and then stuff it and then sew it back.
Interviewer: M-hmm. And [how] did you put things on the outside? First? Or later? Like the eyes?
Rose: Oh, yeah. I put the eyes and the teeth after that, after I was finished [with] the base.
Interviewer: And why did you make them?
Rose: A muffin? Because me and my family like to bake. So, one of the things we bake a lot of [is] mostly cupcakes and cake.

Pedro made a stuffie in the shape of a cross, explaining both how it represented his family and the process he used to make it. He stated, "Because my family's religious. And I made it by drawing it on a piece of paper and I cut out the paper, and I made it on a fabric and I traced and I cut the fabric out with the paper and yeah, I just sewed it."

Serena discussed how she used specific colors in her resin designs as a connection to family members. She stated,

> I did this one [picks up a green ceramic cup] for my mom. I wanted to make her something to have to maybe put her jewelry in, you know, whatever she needs to put in it. I put– chose green because, you know, green is really a kind of like a neutral color. So, I just I freestyled on this one with the green. ... My aunt's favorite color is purple. My aunt passed in 2019. So, I made something that [is] a remembrance of her. So, I just put purple flowers in a purple pigment. So, you know, just get that remembrance.

Youth also discussed the materials, tools, and devices they used to create their designs, which we identified as belonging to subcategory (3.2) *Manufacturing and Tools*. Some of these excerpts were as short as naming the machines they used. For example, Serena said, "I know we used a sand[ing] machine." Sometimes they elaborated on the topic, such as when Pedro shared his sometimes-frustrating experience using a 3D printer, "Yo diría que por suerte. Porque algunos están muy grandes y otros están muy chiquitos. Porque la impresora a veces no puede funcionar tan bien, y tiene problemas al imprimir ciertas piezas. [I would say it was luck. Because some are big and others are small. Because the printer sometimes didn't work as well and it had problems printing certain pieces.]"

Youth in our middle school program worked with CAD software (Tinkercad) and a 3D printer. This drove discussions on the topic of subcategory (3.3) *Computational Tools*, including how they moved between real world measurements and measurements in their 3D designs on the computer.

Rose: We 3D-printed these.
Interviewer: Ah. You did?
Rose: Yeah.
Interviewer: Oh, tell me about that. Me está contando que los imprimieron con la impresora. [She is telling me that they printed them with the printer.]
Pedro: Ah, sí.
Rose: It's on this website called TinkerCad. And we did like, measure it and--
Interviewer: What did you measure?
Rose: With the millimeters. [Rose takes out the ruler from her cubby.]
Interviewer: And what were you measuring? ¿Qué midieron?
Rose: The corners on the box [pointing to the corners]. So, we can put them together ... And then the– we 3D-printed them because we just printed over there ... And then the next time we came over here, we, like, we [stapled] them together to, like, our cubbies.
Pedro: Yeah, we did. Yeah, we got to design them, and we had to make like a specific like size and [opens his hands to indicate a dimension]. Um. We learned how to do, like, three-dimensional shapes to the dimension.

When it came to describing materials, part of subcategory (3.4), youth had opportunities to discuss novel materials, such as when they worked with clay, resin, and metal. Serena discussed carving a flower into a clay piece:

> Interviewer: You mentioned the flower. Is that something maybe that you would like to have worked on more or differently?
> Serena: Yeah.
> Interviewer: What would you have done differently?
> Serena: Not add so much water.

In addition to talking about materials, Serena also talked about how she would do things differently if she got to repeat the project, which is part of TLF's subcategory (1.4) *Iterating*, which we saw earlier.

4. Cultural Knowledge and Skills are the "discussion on navigating a community [in this case, the makerspace community] along with the physical space and what the person comes to understand about that community" (Tomko et al., 2023, p. 6). The subcategories are (4.1) *Access, Conventions, and Protocols*, (4.2) *Roles and Structure of Participation*, (4.3) *Rules of the Community*, and (4.4) *Gender Associations*.

We found that participants often talked about how the program made them feel welcomed and talked about the program's explicit rule of being accepting of everyone and of celebrating experimentation. These comments touched upon elements of all the subcategories withing the (4) *Cultural Knowledge and Skills*, such as access, the structure of participation, and the community's rules. For example, Serena commented,

> It felt great, actually, for me to get out [of] my bubble. I really don't get out of my bubble like that. I normally stay close, have my walls up. So, it's like for me to, you know, get outside my bubble, it was very different. I felt welcomed. I felt, you know, I felt everybody's energy, which was a positive energy. They kept [a] smile on their face, you know, they welcomed me, and they said nice things. So, it was very nice to get to experience that.

Given how exclusionary of youth, women, and people of color spaces dedicated to making can be, participants' comments about feeling welcome in the program were a measure of success for the adults involved.

5. Ingenuity is the "discussion on an informal seeking out solutions or being aware of strategies to use in performing a task" (Tomko et al., 2023, p. 6). Ingenuity subcategories include: (5.1) *Improvisation*, (5.2) *Opportunism*, and (5.3) *Resourcefulness*. We did not find examples of this category in the transcripts of the three participants included here, but other participants did talk about improvising new solutions when something else failed, taking advantage of opportunities to be creative, and being resourceful by using materials in unintended ways.

6. Self-Awareness is the "discussion on the motivating factors toward one's attitude along with one's personal attributes/characteristics" (Tomko et al., 2023, p. 6). The subcodes include: (6.1) *Confidence*, (6.2) *Patience*, (6.3) *Resilience*, and (6.4) *Reflection*. Youth in the program reflected on how much they learned, how they felt about their skill levels, and what they gained from their overall participation, which are part of subcategory (6.4) *Reflection*. For example, Rose described that the applied, contextualized math in the program was "different from what we're learning in class," which was pen-and-paper worksheets, when discussing her stuffie project. She got to apply math to the projects she made in the program, seeing how to use math's to solve problems. Serena also reflected on how she felt about using new machinery, showing self-awareness about her own fears:

> Interviewer: OK. Were any of you afraid to use any of the machines?
> Serena: I was a little bit. Because it's, like, all the orb machine. I don't know. It's just, I don't use the type of materials or machines on a daily basis. So, it was my first time. So, I got a little scared.

Though she was initially scared of the machines, she was able to overcome her fear. Serena also explained that the program helped her be more self-confident and empowered her to follow her aspirations. She stated,

> I feel like the things that we learn here, it's like making us a better person and it's like influenced us to do like, basically, put our minds to what we want to do and like continue going for our dreams. And like, you know, going to that extent where you know you can ask for help when you need it and, like, basically accomplish your dreams. Don't ever be afraid.

5. Limitations

This study's type of data, participants' ages, and the informal learning settings did not match those of Tomko et al.'s (2023) study, which slightly limited the applicability of the TLF. The artifact elicitation interviews in this study were short, which was appropriate for the study's setting and population. However, this also limited the length and depth of discussions with the interviewees, restricting the extent to which

we could observe the modes and products of learning that took place. For example, Pedro and Rose discussed a possible iteration of Pedro's stuffy project and proposed ideas on how to reduce its floppiness. We did not consider their dialogue to fit the TLF's *Learning through Others / Communicating & Managing* category because, while they were engaged in learning through exchange with others, they were not discussing or reflecting upon their learning. Another limitation was the age of this study's participants, with many of our participants being substantially younger than the Tomko et al. (2023) participants. Our participants' younger age meant that they were very aware of age and power differentials with interviewers and were influenced by the presence (or absence) of peers, which affected their willingness to share their ideas and experiences. Conducting group interviews often ameliorated youth's shyness, providing the comfort of a group and opportunities to build on each other's ideas. At the same time, a group setting sometimes triggered giggling sessions or disengaged group attitudes where social pressure superseded the interviewers' efforts to engage the youth in conversation. Including observation data would likely provide examples of some of the subcategories that did not appear in the artifact elicitation interviews.

6. Conclusions

We found the TLF to be applicable to youth of middle and high school age. TLF also helped in identifying some of the learning that happens through making. However, for TLF to better support researchers and educators in making-based informal education programs, we see the need for modifications or extensions. One significant addition that we would make would be to capture learners' motivations for designs and making (e.g., Goldman & Kabayadondo, 2017). The youth in our programs spoke at length about social or relational reasons why they had made things in particular ways. For example, Rose made a stuffie shaped like a muffin, because she and her mother like to bake, and Serena used specific colors in her ceramics work to connect to family members. Because TLF doesn't include a way to identify the aspects of design that involve this communal orientation of making for others, we suggest extending the framework to attend to this critical aspect of making-based learning in informal spaces.

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INTERCULTURAL COMMUNICATION AS A CHALLENGE AND AS A TOOL IN MULTICULTURAL ENVIRONMENTS

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Abstract

Today's world is becoming increasingly multicultural, which means the need for new competencies, especially of communication, in both professional and personal environments. Since a person is a social being and one of the essential characteristics of the latter is the need to communicate, cooperate, and be part of a certain society, communication in this context is an integral part of any society and one of the crucial skills of any person. And here it is important not only to know the language of that society, but also to know essential communication strategies, such as the ability to use various non-verbal means of communication, listen and hear what others say, concentrate, engage and participate in a conversation, speak in public, control your tone of voice, etc. These strategies are especially needed in order to reduce as much as possible the noise that exists in any communication process, which, according to communication experts, not only complicates the communication process itself, but can also negatively affect the results of that communication. In addition to the usual types of noise, such as psychological, physical, physiological, etc., today, culturally based communication noise is increasingly being referred to. This means that cultural characteristics have an impact on how the communication message itself is constructed and sent in the communication process, as well as how it is decoded, i.e. how a person belonging to another culture will understand what was said, how they will react to it, etc. And it is not knowledge of the relevant language, but the existing intercultural communication competence that can help them feel good and act constructively and communicate in a multicultural environment. For these reasons, intercultural communication can pose certain challenges in the communication process, but, on the other hand, having intercultural communication skills can be an excellent tool for communication in a multicultural environment. And the communication could be treated as effective context for development intercultural communication skills and competencies, because practice, reflection and experiential learning are the best ways for developing interculturality in general. The article will examine both of these aspects - as a challenge and as a tool - of intercultural communication, based on the experience of the Siauliai State Higher Education Institution in working with national and international students, it will analyse the challenges encountered in communicating in multicultural environments, and ways in which intercultural communication competencies can be developed during formal and informal studies.

Keywords: *Intercultural communication, multicultural environments, communication strategies, higher education, development of intercultural communication skills and competencies.*

1. Introduction

Today's world is becoming increasingly multicultural, which means the need for new competencies, especially of communication, in both professional and personal environments (Multicultural & Global Literacy – 21st Century Education, 2017). Since a person is a social being and one of the essential characteristics of the latter is the need to communicate, cooperate, and be part of a certain society, communication in this context is an integral part of any society and one of the crucial skills of any person. And here it is important not only to know the language of that society, but also to know essential communication strategies, such as the ability to use various non-verbal means of communication, listen and hear what others say, concentrate, engage and participate in a conversation, speak in public, control your tone of voice, etc. These strategies are especially needed in order to reduce as much as possible the noise that exists in any communication process, which, according to communication experts, not only complicates the communication process itself, but can also negatively affect the results of that communication. In addition to the usual types of noise, such as psychological, physical, physiological, etc., today, culturally

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2. Intercultural communication: Theoretical discourse

Being an integral part of any society and one of the most important skills of any person, high-quality communication is one of the necessary conditions for any process in which more than one person participates. For this reason, the development of communication skills is one of the most important parts of any educational process. Most scientists studying communication processes distinguish such essential elements of the communication process as the sender, the recipient, the content, the channel, the means, as well as feedback (Paulston et al., 2014). The latter is needed in order to understand whether the message sent by the sender is understandable to the recipient, whether the information received by the recipient is as close as possible to the information sent by the sender. On the other hand, it is obvious that due to the psychological, physiological, physical, etc. noise existing in the communication process, there cannot be an absolutely identical understanding of the sent information. This is especially true of intercultural communication, because in this communication process, in addition to the other types of communication noise already mentioned, semantic, in other words, culturally based noise, also appears. This is because the same things can be perceived differently in different cultures, from the perspective of their own culture. For this reason, intercultural communication skills include not only knowledge of various languages, but also other important communication skills. According to many authors, the most important of them are the following (Northup, 2025, Poceviciene, 2021, 2023a, 2023b, 2024a, 2024b, Baraldsnes, 2012; Pruskus, 2012; Paulston et al., 2014):

1. **Active listening.** This is paying attention to the person being communicated with, i.e. the ability to focus only on the speaker, pay attention to his facial expressions and body language, listen to his tone of voice, if necessary, clarify his point of view by asking additional questions or paraphrasing what he said, etc. The practice of active listening can not only establish relationships with the persons participating in the communication process, but also help to receive feedback, understand cultural differences, etc.
2. **Using the appropriate communication methods and channels.** When choosing a communication method, it is very important to consider the audience and the information you want to share. In the case of intercultural communication, direct contact is always better, because there is an opportunity to receive feedback here and now, and if necessary, correct errors or discrepancies that have arisen in the communication process due to communication noise.
3. **Friendliness,** which could also be described as empathy, as the ability to "step into another's shoes", to imagine oneself in another's place. Friendliness greatly strengthens trust in the communication process, and the success of communication itself largely depends on it.
4. **Self-confidence**, which also has a positive effect on the entire communication process, because people are more likely to respond to ideas that are presented confidently. In this context, eye contact, the choice of sitting or standing, and in general, all participation in communication is also important, which can also be understood and expressed differently in different cultural aspects.
5. **Reaction and feedback** to the information provided, it is especially important that they are constructive. Here it should also be remembered that in different cultural contexts people present, receive, and react to information differently, therefore, the perception of the cultural background and its influence can also be treated as an ability for intercultural communication.
6. **Volume and tone**. An important speaking skill is knowing how to be heard clearly. Adjusting your speaking voice to suit different situations is essential for effective communication. And controlling your tone, pitch, emphasis, and pauses can help your audience better understand your message.
7. **Empathy**. This quality can be called “emotional intelligence” and is important both in a team and individually. Listening to other people’s emotions and being able to respond appropriately are factors in successful communication, including intercultural communication.

8. **Respect**, which is usually understood as a general norm and attitude of behaviour, not only enables you to hear and understand the other person better, but is also a means of promoting communication.
9. **Nonverbal language**. People also communicate through nonverbal cues: body language, facial expressions, and eye contact. Most authors believe that we receive much more information through non-verbal language than through verbal language, so if someone uses body language that you are not used to, and in multicultural environments this is not such a rare phenomenon, it is necessary to ask clarifying questions.
10. **Responsiveness**, or rather its speed and quality as well can also be treated as a condition for the success of communication, as in intercultural communication become even more significant due to the cultural differences in their perception

3. Methodology

The main methodological concepts are based on:

- Social constructivism and reconstructivism, which enable critical interpretation of "formed" educational phenomena and understanding them in a sociocultural context. (Berger, Luckmann, 1999; Duoblienė, 2006, and etc.)
- Pragmatism as a philosophy (Dewey, 1966; Bitinas, 2000; Duoblienė, 2006), which emphasizes active participation in learning process by the way of experimenting, solving real life problems, assessing the behavioural effects, active participation in society's life; which also emphasizes the importance of interaction between individuality and society. Learning by doing is one of the most effective teaching / learning methods in intercultural education, because it enables learners not only implement their knowledge into the practice, but also encourage them to reflect the process, to analyse their own and the others experience, and on that base rethink their own behaviour and change it if it's needed.
- Humanistic psychology and pedagogy, where education in a democratic community is characterized by "cooperation, participation in the management of educational institutions, social integration, social responsibility and independent learners learning to enjoy themselves freedom, independence and life can take hold. (Maslow, 1943; Rodgers, 1996 and etc.). In this case the most valuable teaching/learning methods are treated by those who promote students' self-knowledge in the various problem-solving, creative potential, school and social environment relations. This approach is very significant and helpful in intercultural communication, especially in multicultural environments.
- Progressivism philosophy (W. Kilpatric cit. from Duoblienė, 2006; Bitinas, 2000), which emphasizes active person 's participation in his/her own learning process and society 's life too. The principles of progressivism didactics such as individual experience, experimentation, and academicals consulting are very significant for this research.
- "Free" education access (Rogers, 1996; Duoblienė, 2006), which is based on the student's and teacher's interaction, where the student and teacher has to be free to find their own truths, where the learning process is seen as a discovery, learning from their experiences and through his experience as an active and conscious participation in the process. This approach also could be treated as one of the essential approaches in intercultural communication and education.
- The learner-centred conception (Bitinas, 2000; Duoblienė, 2006), which is based on humanism, pragmatism, progressivism ideas about the free, conscious and active personality, which can realize your needs, actively and constructively to solve real life problems, and so on.

3.1. Objectives

The research aimed to theoretically and practically justify intercultural communication process as a challenge and as a tool for development of intercultural communication skills as well as identify the challenges encountered in communicating in multicultural environments, and ways in which intercultural communication competencies can be developed during formal and informal studies.

3.2. Methods

The research consisted of survey and the qualitative analysis of the focus groups discussions about what challenges students experienced working in intercultural groups during different kind formal and unformal activities, what helped or hindered them from working well in those groups, and what could be the ways in which intercultural communication competencies can be developed during formal and informal studies.

3.3. Design

The research was conducted in Šiaulių valstybinė kolegija / Higher Education Institution in 2023-2025 working with intercultural groups in formal (educational activities according to the study subjects) and informal (e.g. Blended Intensive Programmes (BIP). In the research participated 35 students with different cultural, educational, intercultural background. The combination of qualitative and quantitative methods enabled to gather more qualitative results and to create the wider picture of the research topic as well as to suggest more suitable and supportable recommendations for intercultural communication and development of intercultural communication skills which are necessary working in multicultural environments.

4. Discussion

The analysis of the results obtained during the 2023-2025 survey shows that the vast majority (91,4%) of students who participated in various educational activities (both formal, i.e. lectures, seminars, exercises, and informal, i.e. BIP activities) believe that intercultural communication (in other words, tasks and activities that need to be performed in multicultural groups) is an excellent tool for developing intercultural communication skills. The remaining (8,6%), although they agree with this opinion, still see more difficulties and limitations, especially when those activities and tasks are assessed by grades.

Since no significant differences were observed in the responses of students who participated in both formal and informal educational activities, they are all analysed in a common sample.

Analysis of students' opinion about the role of intercultural communication in multicultural environment is presented in Table 1.

Table 1. Students' Opinion about the Role of Intercultural Communication in Multicultural Environment.

Subcategories	Statements
Positive	*"Clear communication and clear instructions helped us work well as a team"* *"[...] the collaboration was effective thanks to good communication and involvement [...]"* *"[...] it was easy to communicate and organise outings outside the planed ones as a group and get to know each other."* *"We also had good communication and mutual respect, which allowed us to work efficiently and share responsibilities[...]"*
Helpful, supportive	*"Here really helped that our groups were all mixed from different universities so that we got to know all participants[...]"* *"[...] one factor that really helped our team collaboration was the diversity of perspectives. Each group member brought unique ideas based on their cultural background, which made our discussions richer and more creative."* *"[...] these difficulties became learning opportunities, we had to practice patience, active listening, and adaptability, which are essential global competencies."*
Challenges	*"Since all came from different backgrounds (especially different cultures) was a high-end awareness there that misunderstandings can occur."* *"In the most cases these misunderstandings where simple to solve through concrete questions and clear communication."*
Restrictions	*"Some members didn't understand English and they wanted to work with their friends[...]"* *"It was harder to work because of our different accent"* *"Working in an international group was enriching but sometimes challenging because of language barriers and different working styles[...]"* *"Sometimes, differences in communication style or expectations about deadlines made it harder to stay coordinated"* *"In a few cases, language barriers or hesitancy to speak openly created small misunderstandings[...]"*

Based on the analysis of qualitative data, it can be stated that most students see more positive, even encouraging, engaging, motivating and helpful things in intercultural communication than negative or problematic things. As the students themselves say, intercultural communication even significantly supplemented their learning outcomes, increased the efficiency of their educational process, because it enabled them to look at the same things and situations from different cultural perspectives. During intercultural communication, they also got to know other cultures better, as well as their own, because high-quality and constructive intercultural communication is always a dialogue between cultures.

The problems that arise in this are mostly related to the knowledge/lack of knowledge of the language itself, but not to the communication process itself.

5. Conclusions

- The study theoretically and practically substantiated that in a multicultural environment the process of intercultural communication can be treated as a challenge and as a means for developing intercultural communication skills.
- The use of various formal and informal intercultural communication competence activities is an effective means and educational environment for the development of intercultural competences
- In order to identify the challenges arising in this process, it is obvious that the respondents themselves see more advantages than disadvantages in intercultural communication. Moreover, the latter are mainly related to language proficiency/inability, and not to the communication process itself and during it, due to various cultural differences, communication noises that may arise.

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DEVELOPING A FRAMEWORK FOR THE INTEGRATION OF EDUCATION FOR SUSTAINABLE DEVELOPMENT INTO SCIENCE TEACHING AND LEARNING

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Abstract

Global efforts to embed Education for Sustainable Development (ESD) into curricula, particularly science education, are gaining traction. Yet research highlights that teachers often lack a clear understanding of sustainability objectives, competencies, and pedagogies. This gap is largely due to the absence of frameworks guiding the integration of ESD into science lessons, to align with the 2030 Agenda for Sustainable Development. To address this, the study developed a practical, comprehensive, and cohesive framework incorporating ESD principles. Using a qualitative conceptual design, the study developed a framework which outlines SDG-specific learning objectives, sustainability competencies, and transformative pedagogies to develop the competences in learners. The framework is expected to strengthen teachers' grasp of ESD and empower them to integrate it in their teaching to cultivate a generation of students equipped to tackle sustainability challenges.

Keywords: *Education, science, ESD, sustainability, framework.*

1. Introduction

The global community faces urgent challenges such as climate change, hunger, conflict, and inequality (UNESCO, 2015), prompting UNESCO to introduce the 2030 Agenda for Sustainable Development, which is built around 17 Sustainable Development Goals (SDGs) (UNESCO, 2015). Education for Sustainable Development (ESD) is central to achieving this agenda, as it equips learners with the knowledge, skills, and values necessary to advance global sustainability (UNESCO, 2017). Yet many teachers struggle to integrate the SDGs into their lessons due to limited understanding and the absence of clear pedagogical frameworks (de Souza, 2025). To address this gap, the study proposes a framework that outlines SDG-specific objectives, transformative teaching approaches, and targeted competencies to support science educators in embedding sustainability into their practice.

2. Literature review

2.1. Education for sustainable development in science education

Science education provides fertile ground for embedding ESD due to its emphasis on inquiry, evidence-based reasoning, systems thinking, and ethical reflection (Vilmala et al., 2022). However, studies reveal that sustainability principles are often included unintentionally, superficially, with some key competencies absent, and teachers lacking sufficient knowledge of ESD (Kazeni & Nyamupangedengu, 2025; Rieckmann, 2018; Khadim et al., 2022). Moreover, many teachers lack training, institutional support, and clarity on how to translate ESD principles into classroom practice (UNESCO, 2021). Policy commitments frequently fail to materialize due to resource constraints and systemic barriers (de Souza, 2025). These findings underscore the need for structured guidelines to support adequate and intentional ESD integration.

2.2. Approaches for integrating sustainable development (ESD) into education

Existing approaches to integrating Education for Sustainable Development (ESD), which include transformative pedagogy, curriculum integration, whole-school strategies, and community engagement, show promise but face challenges such as resource limitations, curriculum overload, and uneven implementation (Azmi et al., 2024; Roach, 2023). Moreover, a systematic review conducted by Habibaturrohmah et al. (2023) highlights strategies for integrating ESD into STEM education, such as

embedding SDG concepts into lesson, hands-on projects, real-world problem-solving, community partnerships, and teacher training. However, these remain fragmented due to resource constraints (Azmi et al., 2024), institutional inertia, siloed curricula, and limited teacher confidence. As UNESCO (2021) stresses that sustainability begins with teachers, this study proposes a comprehensive framework combining UNESCO's ESD model with UCL's integration guidelines. By offering structured, practical guidance, the framework aims to build teacher capacity to embed sustainability principles into science education without major curricular changes, thereby cultivating learners who are equipped to promote sustainability.

2.3. Theoretical foundations of the developed ESD integration framework

Effective integration of Education for Sustainable Development (ESD) into curricula requires teachers to have a clear understanding of sustainability competencies, ESD principles, and integration pedagogies, which are key components of the UNESCO ESD framework (UNESCO, 2017). Guided by UNESCO's ESD framework (2017) and the integration steps outlined in the University College London (UCL) toolkits (Roach, 2023), this study developed a framework for embedding ESD into science lessons. The UNESCO ESD framework is described in detail in Section 4 below. The UCL toolkits propose five steps for integrating ESD into teaching: reflecting on current practice, identifying relevant topics, adopting active and critical pedagogies, aligning assessment with sustainability learning, and building supportive networks (Roach, 2023).

3. Methodology

The study employed a qualitative conceptual design, a systematic interpretive research process for constructing theoretical frameworks by analysing existing literature, policies, and expert perspectives (Creswell et al., 2018). Data was collected through a systematic literature review, document analysis, and semi-structured interviews. The documents analyzed included UNESCO's 2030 Agenda for Sustainable Development, Education for Sustainable Development (ESD) guidelines (UNESCO, 2017; Byers et al., 2024), and South African science curricula (Natural Sciences, Life Sciences, and Physical Sciences [Department of Basic Education, 2011]). These documents were examined to identify (i) sustainability learning objectives, (ii) competencies critical for advancing sustainability, and (iii) transformative pedagogical approaches effective in cultivating sustainability competencies.

In addition, seven science lecturers from a South African university participated in semi-structured interviews to determine whether they integrate ESD into their lessons and to identify gaps and opportunities for improved integration. Data from these sources were then used to develop a framework for embedding ESD into science lessons.

4. Results: The developed framework

Scholars argue that cohesive frameworks are essential for guiding teachers in embedding ESD into science lessons (Shumba & Kampamba, 2013). Combining the UCL-ESD integration steps ESD principles, and insights from lecturer interviews led to the development of a framework for integrating ESD into science lessons. This practical framework is designed to help teachers apply ESD principles without deviating significantly from their usual pedagogical practices. Its purpose is twofold: (1) to provide teachers with accessible sustainability learning objectives, sustainability competences, and transformative pedagogies, and (2) to offer a stepwise integration of ESD principles for fostering sustainability competencies.

ESD principles are organized into three components: (1) SDG-specific learning objectives, (2) cross-cutting sustainability competencies, and (3) transformative pedagogies, consistent with the UNESCO ESD framework (2017).

4.1. SDG-specific learning objectives

SDG-specific objectives are framed within cognitive, socio-emotional, and behavioural domains.

- *Cognitive domain*: Focuses on knowledge and critical thinking skills needed to understand the SDGs and their challenges. These learning objectives include content from the three pillars of sustainability (environmental, social, and economic), established at the Rio Earth Summit (Lanchberry, 1996).

i. *Environmental pillar:* includes ecosystem protection, resource management, and climate action, linked to SDGs 6, 7, 13, 14, and 15.

ii. *Social pillar:* comprises attributes such as equity, justice, human rights, and community well-being, linked to SDGs 1, 2, 3, 4, 5, 10, and 16.

iii. *Economic pillar: involves* growth, innovation, and responsible consumption aligned with sustainability, linked to SDGs 8, 9, 11, and 12. Teachers can select objectives based on grade, topic, and context.

These pillars are interconnected and mutually reinforcing, forming the foundation of the 17 SDGs (Purvis et al., 2019).

- *Socio-emotional domain:* Involves skills such as self-reflection, empathy, emotional intelligence, values, and attitudes that raise awareness of sustainability issues. Activities foster collaboration, negotiation, and communication.
- *Behavioural domain:* Encompasses action competencies that encourage learners to promote and model behaviours supporting the SDGs (UNESCO, 2017). This domain is seldom integrated into science teaching (Kazeni & Nyamupangedengu, 2025).

Science teachers must understand the SDG-specific learning objectives across these three domains to effectively and intentionally incorporate them into lessons.

4.2. Cross-cutting key ESD competencies

Cross-cutting competencies enable individuals to engage responsibly with complex global issues. They are transversal, multifaceted, and context-independent, empowering learners to address sustainability challenges. Table 1 outlines these key competencies (UNESCO, 2017).

Table 1. cross-cutting key ESD competencies.

Cross-cutting Key Competency		Description
1	*Systems thinking*	The ability to recognize and understand relationships; to analyse complex systems; to think of how systems are embedded within different domains and different scales; and to deal with uncertainty.
2	*Anticipatory /Futures thinking*	The ability to understand and evaluate multiple futures; possible, probable and desirable; to create one's own visions for the future; to apply the precautionary principle; to assess the consequences of actions; and to deal with risks and changes.
3	*Normative / Value thinking*	The ability to understand and reflect on the norms and values that underlie one's actions; and to negotiate sustainability values, principles, goals, and targets, in a context of conflicts of interests and trade-offs, uncertain knowledge and contradictions.
4	*Strategic thinking*	The ability to collectively develop and implement innovative actions that further sustainability at the local level and further afield.
5	*Collaboration*	The ability to learn from others; to understand and respect the needs, perspectives and actions of others (empathy); to understand, relate to and be sensitive to others (empathic leadership); to deal with conflicts in a group; and to facilitate collaborative and participatory problem solving.
6	*Critical thinking*	The ability to question norms, practices and opinions; to reflect on own one's values, perceptions and actions; and to take a position in the sustainability discourse.
7	*Self-awareness*	The ability to reflect on one's own role in the local community and (global) society; to continually evaluate and further motivate one's actions; and to deal with one's feelings and desires.
8	*Integrated problem-solving*	The ability to apply different problem-solving frameworks to complex sustainability problems and develop viable, inclusive and equitable solution options that promote sustainable development, integrating the above-mentioned competences.

4.3. Transformative pedagogies

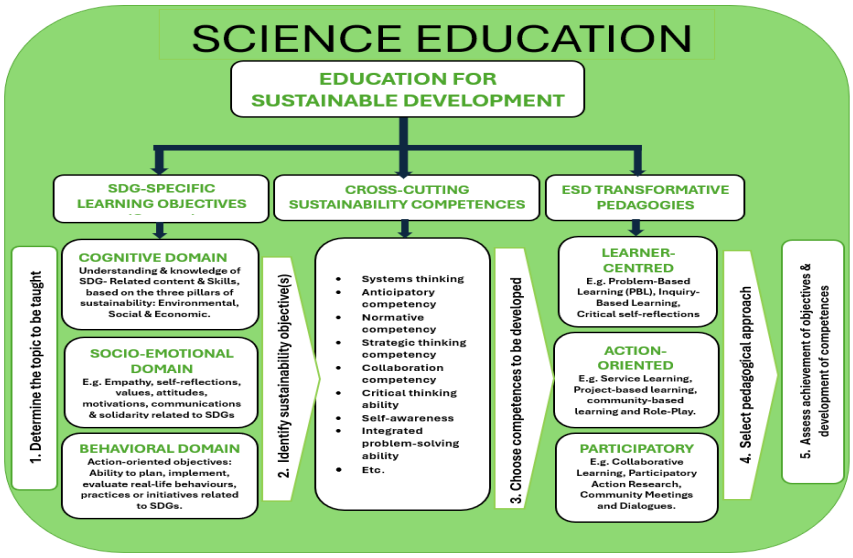
Transformative ESD pedagogies are grouped into three categories: learner-centred, action-oriented, and participatory (UNESCO, 2017). *Learner-centred* approaches encourage critical reflection, with educators acting as facilitators, using methods such as inquiry-based learning, experiential learning, self-reflection, game-based learning, Socratic dialogue, portfolio assessment, and collaborative learning. *Action-oriented* pedagogies engage students in real-world activities followed by reflection, linking abstract concepts to lived experiences. Strategies include project-based learning, internships, community-based learning, fieldwork, service learning, sustainability labs, and workshops. *Participatory* pedagogies empower learners to challenge assumptions, shift perspectives, and reimagine worldviews through active dialogue and engagement. Techniques include Problem-Based Learning, Participatory Action Research, scenario building, theatre, role play, simulations, and participatory decision-making.

Based on the steps outlined in the UCL toolkits (Roach, 2023), the developed framework suggests the following process for integrating ESD into science lessons.

1. Determine the science topic or concept to be taught.
2. Identify relevant SDG-specific learning objectives from cognitive, socio-emotional, or behavioural domains.
3. Select cross-cutting sustainability competencies to be developed alongside the topic.
4. Choose transformative pedagogies to deliver the content, achieve objectives, and foster competencies.
5. Assess students on their understanding of both the topic and sustainability competencies.

A combination of the described learning objectives, sustainability competencies, transformative pedagogies, and the ESD integration steps from the UCL toolkits has resulted in the following framework for integrating Education for Sustainable Development (ESD) into science lessons.

Figure1. Diagrammatic representation of the developed ESD integration framework.



By using this framework, teachers can integrate SDG-specific objectives and sustainability competencies into science lessons in a consistent and systematic manner without deviating from the curriculum or requiring additional instructional time.

5. Discussion of result

Since ESD integration primarily occurs in classroom practice, frameworks must clearly articulate SDG-specific objectives, identify relevant content, and recommend pedagogical strategies aligned with sustainability competencies (UNESCO, 2017). Research highlights that teachers often lack adequate knowledge of ESD principles and when they embed them, they usually do so unintentionally (Khadim et al., 2022; Rieckmann, 2018). Structured frameworks can therefore provide clarity and empower educators to integrate ESD consistently across science curricula. The framework developed in this study addresses this need by outlining both the principles to be incorporated and the steps for integration.

Aligned with UNESCO's 2030 Agenda and national education policies, the framework is designed to enhance teacher preparedness, build confidence, and encourage intentional integration without requiring major changes to existing practices. Nonetheless, challenges remain, particularly the need for teachers to master transformative pedagogies and understand sustainability competencies in depth.

6. Conclusion

The developed framework offers:

- A structured approach to integrating ESD into science teaching.
- Teachers' accessibility to sustainability objectives, competencies, and pedagogies.
- A stepwise guidance for embedding sustainability objectives and competencies into lessons.
- A method for integrating ESD into lessons without deviating from the curriculum and usual teaching practices.

If widely adopted, this framework has the potential to significantly advance sustainability education. Future research should focus on empirical testing and validation across diverse contexts.

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CBL PROJECT AND SUSTAINABILITY – SARRIKO SUSTAINABLE: THE CHALLENGE TO REDUCE, REUSE AND RECYCLE

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Abstract

Waste generation and inadequate management represent one of the most pressing environmental challenges of contemporary societies due to their direct contribution to climate change, biodiversity loss, and resource depletion. Higher Education Institutions (HEIs), as complex socio-technical systems characterized by high population density and turnover—including students, faculty, researchers, and administrative and service staff—generate a significant material footprint associated with their academic, research, and operational activities. Within this framework, the University of the Basque Country (EHU) has positioned the 2030 Agenda as a cross-cutting strategic axis, embedding sustainability principles into governance, teaching, research, and knowledge transfer through initiatives such as *EHUagenda2030 for Sustainable Development*. Aligned with this institutional strategy, the Faculty of Economics and Business promotes the collective initiative "SARRIKO SUSTAINABLE: The Challenge to Reduce, Reuse, and Recycle." The project aims to foster a structural transformation in consumption patterns and waste management practices on campus, advancing beyond recycling performance toward waste prevention at source and measurable reductions in overall waste generation, consistent with circular economy and zero-waste frameworks. The overarching objective is to empower students as active change agents through the implementation of the Challenge-Based Learning (CBL) methodology. By integrating experiential learning, systems thinking, and collaborative problem-solving, the initiative seeks to generate feasible, scalable, and impact-oriented solutions. The project incorporates environmental performance indicators and impact assessment mechanisms to support evidence-based decision-making and facilitate the campus transition toward a more sustainable and resource-efficient model.

Keywords: *CBL, EHU, sustainability, climate change, zero-waste.*

1. Introduction and institutional framework

Recycling behavior in university settings has been widely studied as part of broader sustainability efforts in higher education. Universities function not only as educational institutions but also as micro-societies where environmental culture, infrastructure and behavioral norms interact. Research consistently highlights that pro-environmental behavior emerges from a combination of **individual attitudes and institutional context** (Kollmuss & Agyeman, 2002; Vicente-Molina et al., 2013).

One of the most influential frameworks explaining environmental behavior is the **Attitude–Behavior Gap**, which states that high concern for the environment does not necessarily translate into concrete, consistent action (Kollmuss & Agyeman, 2002). This gap appears clearly in recycling behavior, where intention often exceeds actual practice, particularly in campus environments where situational barriers can be substantial.

Several studies emphasize that **environmental knowledge**—particularly knowledge about what can be recycled and how—is positively associated with recycling rates (Saphores et al., 2012; Vicente-Molina et al., 2013). While general awareness tends to be high among university students, detailed knowledge about specific waste streams (e.g., batteries, electronic waste, hazardous residues) remains low, creating inconsistencies in recycling behavior.

Infrastructure availability and accessibility are among the most powerful predictors of recycling behavior on campus (Davis et al., 2006; Menegaki et al., 2009). The presence, proximity, visibility and clarity of recycling containers greatly influence whether individuals engage in pro-environmental acts. Poor signage or bin contamination, frequently reported issues in higher education institutions, reduce the effectiveness of recycling systems and discourage participation.

Gender differences in environmental attitudes have been consistently documented. Women generally show greater pro-environmental concern and are more likely to adopt sustainable habits (Vicente-Molina et al., 2013). However, the interaction between gender and commitment does not always translate into stronger recycling behavior in multivariate analyses, particularly when contextual barriers are strong.

Research also emphasizes the role of **habit formation**. Students who recycle regularly at home are significantly more likely to do so on campus (Barr, 2007; Schultz et al., 1995). Habitual recycling reduces the cognitive burden associated with sorting waste and increases the likelihood of consistent pro-environmental behavior across settings.

In line with these studies, the findings from the Faculty of Economics and Business also confirm that household recycling habits—especially paper and cardboard separation—are strongly associated with campus recycling behavior. Likewise, infrastructural barriers (lack of bins, confusing signage) appear as the main explanations for the attitude–behavior gap observed.

Overall, the literature suggests that effective campus recycling programs must combine **structural improvements**, **behavioral nudges**, and **educational communication strategies**, since interventions focusing solely on attitudes are insufficient when the physical recycling environment is inadequate

Waste generation and management constitute a critical environmental challenge due to their contribution to greenhouse gas emissions, ecosystem degradation, and resource depletion. Within this context, Higher Education Institutions (HEIs) operate as complex socio-technical systems with significant material throughput derived from teaching, research, administrative, and service activities. As knowledge-producing and norm-setting organizations, universities are uniquely positioned not only to reduce their environmental footprint but also to catalyze behavioral and systemic change.

The University of the Basque Country (EHU) has integrated the 2030 Agenda for Sustainable Development as a cross-cutting strategic axis in its institutional policy framework. Through initiatives such as *EHUagenda2030 for Sustainable Development*, sustainability principles are embedded across governance structures, curricula, research agendas, and community engagement strategies. This alignment reflects an understanding of universities as transformative agents capable of advancing Sustainable Development Goals (SDGs), particularly SDG 12 (Responsible Consumption and Production) and SDG 13 (Climate Action).

In alignment with this institutional commitment, the Faculty of Economics and Business launched the collective initiative **"SARRIKO SUSTAINABLE: The Challenge to Reduce, Reuse, and Recycle."** The project responds to the need for a structural transformation in campus waste management practices, moving beyond isolated recycling actions toward a comprehensive zero-waste and circular economy framework.

The initiative is grounded in three core premises:

1. Waste reduction must prioritize prevention at source rather than downstream recycling alone.
2. Behavioral change is as important as infrastructural improvement.
3. Students must be positioned as active agents of institutional transformation.

Thus, the project combines operational sustainability goals with pedagogical innovation, integrating environmental performance improvement with competence-based education.

2. Methodological design: Challenge-based learning as a transformative tool

The project adopts the Challenge-Based Learning (CBL) methodology as its pedagogical backbone. CBL is an experiential, student-centered approach that engages learners in solving real-world challenges through inquiry, collaboration, and iterative solution design. Unlike traditional project-based models, CBL emphasizes systemic analysis, stakeholder engagement, and measurable impact.

2.1. Research-action framework

The initiative follows a research-action model structured in four phases:

Phase I: Diagnosis and baseline assessment

The first phase focused on constructing a comprehensive diagnosis of waste generation and management within the faculty building. Rather than limiting the analysis to quantitative waste volumes, the diagnostic process aimed to understand the campus as an interconnected system of material flows, behaviors, infrastructures, and institutional norms.

A waste audit was conducted to quantify the main waste streams generated in academic and administrative activities. Particular attention was paid to packaging consumption, single-use packaging, organic waste from common areas, and electronic waste associated with technological equipment. In parallel, spatial mapping of waste collection points was undertaken to evaluate accessibility, visibility, and functional design.

Complementing the material analysis, a behavioral assessment was carried out through surveys and structured observations. This allowed the identification of discrepancies between declared environmental awareness and actual disposal practices. The diagnostic phase revealed that although recycling infrastructure was present, inefficiencies were generated by inadequate signage, contamination of separated fractions, and limited understanding of the environmental consequences of improper disposal.

The outcome of this phase would be the establishment of a baseline dataset including per capita waste generation, separation efficiency rates, and contamination levels. These indicators would provide an empirical foundation for subsequent interventions and enabled the formulation of measurable objectives.

Phase II: Challenge definition and problem framing

Building upon the diagnostic findings, the second phase consisted of reframing waste management from an operational issue into a strategic challenge requiring systemic solutions. Students were invited to analyze the collected data and identify leverage points capable of producing structural change.

Rather than prescribing predefined problems, the methodology encouraged students to construct the challenge through guided inquiry. This process led to the identification of several interconnected issues: excessive reliance on recycling rather than prevention, normalization of single-use consumption practices, and limited feedback mechanisms regarding environmental performance.

Through facilitated workshops, students reformulated these issues into actionable challenges articulated around measurable impact goals. The reframing process shifted the focus from “improving recycling rates” to “reducing waste generation at source” and from “providing information” to “modifying behavioral incentives.” This conceptual shift was critical in aligning the project with circular economy principles and zero-waste strategies.

The challenge-definition phase thus functioned as a cognitive transformation process, enabling participants to move from fragmented observations toward systemic understanding.

Phase III: Solution co-design and prototyping

The third phase involved the collaborative design of interventions capable of addressing the identified leverage points. Interdisciplinary student teams developed proposals integrating behavioral, infrastructural, technological, and governance dimensions.

Some teams focus on behavioral economics strategies, designing nudging interventions aimed at improving separation accuracy and reducing contamination rates. Others propose redesigns of bin placement and signage to enhance visibility and intuitive use. Additional initiatives include awareness campaigns grounded in data visualization, as well as digital dashboards to communicate real-time environmental performance indicators to the university community.

The co-design process emphasizes feasibility, scalability, and impact measurability. Each proposal requires to define specific Key Performance Indicators (KPIs) and an evaluation plan. This requirement reinforces evidence-based reasoning and strengthened analytical competencies.

Prototyping are conducted at a small scale within selected areas of the Faculty. The iterative nature of the methodology allowed teams to refine interventions based on feedback and preliminary results, fostering adaptive learning and continuous improvement.

Phase IV: Implementation and impact evaluation

The final phase will focus on pilot implementation and systematic impact assessment. Selected interventions will deploy in real campus settings over a defined evaluation period. Quantitative indicators—such as reductions in total waste volume, improvements in separation rates, and decreases in contamination—will be measured against the baseline established in Phase I.

Simultaneously, qualitative data were collected through follow-up surveys and focus groups to assess shifts in environmental awareness, perceived responsibility, and sense of agency among participants. The integration of quantitative and qualitative evidence enabled a multidimensional evaluation of outcomes.

Preliminary results indicate measurable improvements in separation efficiency and a moderate reduction in mixed waste generation in pilot areas. More significantly, the process contributed to a cultural shift in which sustainability was increasingly perceived as a shared institutional responsibility rather than an external administrative mandate.

The evaluation phase also will generate strategic recommendations for scaling the initiative across other faculties, demonstrating the model's transferability.

3. Discussion: Educational and institutional implications

The SARRIKO SUSTAINABLE initiative illustrates the potential of integrating sustainability governance with pedagogical innovation. By embedding environmental challenges within curricular activities, the project transforms the campus into a living laboratory for sustainable transition.

From an educational perspective, the CBL methodology enhances systems thinking, collaborative problem-solving, and data-driven decision-making. Students engage with real institutional constraints, negotiate stakeholder interests, and confront the complexity inherent in sustainability transitions. This experiential dimension strengthens both cognitive and ethical competencies.

From an institutional perspective, the initiative contributes to operational sustainability while fostering participatory governance. The incorporation of measurable environmental indicators supports accountability and evidence-based management. Furthermore, the project reduces the gap between institutional sustainability discourse and daily practices.

Importantly, the initiative reveals that infrastructural improvements alone are insufficient. Behavioral and cultural dimensions are central to achieving durable change. Universities must therefore design sustainability strategies that integrate structural redesign with participatory engagement mechanisms.

4. Conclusions

The transition toward sustainable and circular waste systems in Higher Education Institutions requires systemic, participatory, and evidence-based approaches. The SARRIKO SUSTAINABLE initiative demonstrates that Challenge-Based Learning provides a robust framework for aligning environmental performance improvement with transformative education.

First, the project confirms that universities can function as experimental ecosystems where sustainability challenges are addressed through collaborative innovation. By positioning students as co-creators of solutions, the initiative strengthens institutional ownership and long-term commitment.

Second, the findings underscore the importance of prioritizing waste prevention and behavioral change over downstream recycling strategies. Structural redesign must be accompanied by cognitive and cultural transformation.

Third, the integration of environmental KPIs and impact assessment mechanisms enhances governance quality and supports informed decision-making. Sustainability becomes measurable, monitorable, and strategically embedded.

Fourth, the initiative offers a scalable and replicable model adaptable to other faculties and institutions. Its modular design and evidence-based methodology facilitate transferability across contexts.

Ultimately, the project moves beyond symbolic adherence to the 2030 Agenda and demonstrates how sustainability can be operationalized through the convergence of pedagogy, governance, and community engagement. By transforming the campus into a living laboratory for circular economy practices, SARRIKO SUSTAINABLE contributes to redefining the role of higher education in addressing global environmental challenges.

There is still a long way to go in this project that grows in numbers and interest every day.

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A PILOT STUDY ON THE EFFECTS OF INVOLVING THE SECONDARY SCHOOL STUDENTS IN JAR (JUNIOR ACHIEVEMENT - ROMANIA) ACTIVITIES ON THEIR ENTREPRENEURIAL INTENTIONS

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Abstract

In an ever-evolving society, education plays a crucial role in preparing students for successful careers. Beyond the content of the mandatory school subjects, students also need additional knowledge and skills to prepare them for the labor market. Entrepreneurship education plays a significant role in developing entrepreneurial intentions among young people. The pilot study presented in this paper analyzes the effects of involving secondary school students in Junior Achievement Romania (JAR) activities. The study focuses on how participation in JAR programs contributes to changes in students' attitudes toward entrepreneurship, the entrepreneurial skills they develop, and their intentions to start a business. The study included four classes of students from two different schools in Bucharest, Romania. A comparison was made between the two student groups, and data were collected through a questionnaire administered to the students. The results show that Junior Achievement Romania (JAR) activities have a positive influence on changing students' attitudes toward entrepreneurship and on developing their entrepreneurial skills. Furthermore, the data indicates that students exposed to JAR activities exhibit higher self-confidence and show greater interest in starting a business. This pilot study serves as a starting point for future research on this topic and provides teachers and other educational stakeholders with useful recommendations regarding the role and importance of promoting entrepreneurship among young people. However, the study also has limitations, including the small number of students involved and the lack of longitudinal data.

Keywords: *Junior Achievement - Romania – JAR, entrepreneurial education, business education.*

1. Introduction

The labor market is in a continuous state of change, leading to the need for lifelong development among employees. Consequently, this generates a new responsibility for education, namely preparing students for a future of continuous development. Another essential aspect is the development of career competencies (Kuijpers, 2025).

Since the entrepreneurial environment is also undergoing multiple changes, teachers must pay close attention to how they adapt the educational process, procedures, and curriculum to ensure that future entrepreneurs achieve the best possible outcomes. In higher education, there is a competitive market that provides incentives to attract aspiring entrepreneurs through relevant programs that contribute to the success of new ventures. Moreover, changes in the entrepreneurial environment have also led to shifting expectations regarding educational programs (Bauman & Lucy, 2021).

The multitude of changes in market conditions and technology has generated new job requirements, prompting recruitment managers to seek candidates who possess a strong set of competencies capable of responding to increasingly complex demands (Bullen et al., 2020). The expansion of mass higher education has intensified competition among graduates in the labor market. Students realize that obtaining a degree is not sufficient to secure employment and are aware that they need added value and distinctive elements in their qualifications to gain a competitive advantage. Extracurricular activities play a fundamental role in this process, enabling students to acquire and demonstrate competencies that may not be visible in their CV due to a lack of professional experience (Roulin & Bangerter, 2013).

2. Literature survey

In higher education institutions, globalization imposes new challenges. Teachers focus primarily on providing an extensive set of competencies required for the new knowledge-based economy. Educational managers must create an effective learning environment that supports sustainable learning and enables students to successfully face emerging challenges. An effective way to prepare students for productive and fulfilling careers in today's economy is through an integrated educational environment that offers students the opportunity to develop their creative potential (Stukalina, 2008).

Entrepreneurial learning in higher education, based on successful entrepreneurial models, contributes to the promotion of education for sustainable development. Several theoretical perspectives, such as human capital, entrepreneurial self-efficacy, and self-determination, support the idea that entrepreneurial education is positively correlated with students' entrepreneurial intentions, providing them with the knowledge and skills needed to motivate the development of their entrepreneurial careers. Exposure to successful entrepreneurial models within entrepreneurship education programs is a key factor in boosting students' confidence in their ability to start a business and in improving their attitudes toward entrepreneurship (Boldureanu et al., 2020).

A study exploring methods and strategies for preparing students to succeed professionally in a changing business society suggests that integrating real-world experiences through internships, developing critical thinking and problem-solving skills, and promoting lifelong learning and personal development are effective ways to prepare students for a successful business career. The study also emphasizes the use of technology and digital tools to enhance students' career prospects in the business sector (Grigorescu, 2024).

Research conducted to evaluate career counseling needs among 3,562 junior high students in southern Alberta analyzed the relevance of career planning, the people students would turn to for career guidance, and the type of support they desired in the planning process. The results indicate that career planning is important for junior high students, who primarily rely on parents and friends when making decisions about their future careers. Regarding the support they desire, students emphasized access to relevant information and assistance in choosing appropriate courses (Bardick et al., 2004). Overall, there is a consensus that students' attitudes toward entrepreneurs, entrepreneurial activity, and its social role are determining factors for those pursuing an entrepreneurial career. A study comparing students' attitudes toward entrepreneurship and business formation in Catalonia and Puerto Rico, with samples of 837 and 435 students respectively, found that students generally have a positive view of entrepreneurship. Both groups showed favorable perceptions of the desire to start a business, even if feasibility perceptions were not as positive, and a small percentage expressed intentions to start a new company (Veciana et al., 2005).

A survey titled "Perceptions of Entrepreneurship among Future Creative Professionals," conducted with 475 students from Estonia, Latvia, and Finland, analyzed the attractiveness of entrepreneurship and students' opinions regarding motivational factors and barriers they anticipate in pursuing an entrepreneurial career. For Estonian students, motivational factors were related to the nature of entrepreneurial work, specifically interesting tasks and responsibilities, and the extensive freedom to manage their own activities and schedules. The main barriers mentioned were financial insecurity in entrepreneurship and the high costs of funding a venture. Differences were also noted between younger and older students: younger students valued interesting entrepreneurial tasks and responsibilities more, while older students emphasized freedom and independence. The authors concluded that a flexible and differentiated learning design, adapted to students' needs, is essential. Another conclusion was that most students exhibited a low entrepreneurial attitude, with very few having experience in starting or managing entrepreneurial activities, developing projects, or founding civic organizations (Kaseorg & Raudsaar, 2013).

An organization in Romania that is actively involved in developing entrepreneurial education among young people is Junior Achievement. This is the largest international organization focused on economic and entrepreneurial education, with programs in 40 countries across Europe and over 100 worldwide. In Romania, more than 307,000 young people from over 1,900 pre-university and higher education institutions take part annually in JA's applied learning and project-based programs, projects and competitions developed in partnership with the Ministry of Education and Research, educational institutions and JA supporters in Romania.

3. Methodological approach

The present research is a pilot, exploratory, and comparative study, conducted with the aim of analyzing the effects of involving eighth-grade students in activities carried out through the Junior Achievement Romania (JAR) program on their entrepreneurial intentions, attitudes toward entrepreneurship, and perceptions regarding the development of career-relevant competencies.

The research methodology is quantitative, using a questionnaire consisting of 9 questions. The first seven questions were single- or multiple-choice and focused on students' experience in entrepreneurship, the professional fields they consider for a future career, the qualities and skills they deem necessary for an entrepreneurial career, their level of awareness regarding JAR, and their perception of how these activities contribute to the development of entrepreneurial competencies and other skills relevant to future careers, as well as their intentions to start a business in the future. Additionally, the questionnaire included two open-ended questions aimed at identifying the school subjects students consider useful for their future careers and the school counseling services they consider relevant for career guidance.

The questionnaire was administered in paper format to students from four classes across two schools in Bucharest, Romania, with a total of 70 participants. Data were collected in February 2026 and analyzed using descriptive statistics (frequencies and percentages), comparisons between student groups (JAR participants and non-participants), while responses to the open-ended questions were analyzed thematically, identifying recurring categories regarding subjects perceived as relevant for careers and counseling services considered useful. The study employed a comparative approach between students involved in JAR activities and those who did not participate. The purpose of the comparison was to identify differences in students' experience and intentions regarding entrepreneurship, their perception of JAR's contribution to developing entrepreneurial competencies, and their career orientation within the school context.

4. Findings

For the analysis of the data and the extraction of conclusions regarding the effects of students' involvement in entrepreneurial activities, the results are presented as follows: Group 1 consisted of 33 students who participated in activities organized through the Junior Achievement Romania (JAR) program, while Group 2 included 37 students who did not participate in this program.

First, to analyze students' experience with entrepreneurial activities, they were asked whether they had any experience they considered *"entrepreneurial".* Analysis of responses from both groups showed no major differences. In both groups, there were students who reported not participating in such activities and others who had participated in one or more activities. Regarding examples of entrepreneurial activities, most students in both groups mentioned activities involving product sales. The second most common activities were creating a game, application, or website, followed by involvement in a family business. Some students from both groups also mentioned having developed business plans.

To examine students' teamwork abilities and self-confidence, skills essential for entrepreneurship, they were asked what they do when faced with a difficult problem. Four response options were provided, along with the possibility of giving an open-ended answer. Most students in Group 1 (16) chose *"I look for additional information and useful resources",* while most students in Group 2 (18) *chose "I try to solve it myself until I find a solution".* This indicates that students in Group 1 show higher self-confidence while also recognizing the need for additional resources. Another difference was observed in the number of students who chose *"I ask for help immediately":* 3 students in Group 1 compared to 8 in Group 2. Thus, students in Group 1 tend to be more resilient to frustration and persist with challenging tasks.

Table 1. Students' approaches to solving difficult problems.

	Group 1	**Group 2**
Ask for help immediately	3	8
Look for information/resources	16	6
Communicate with my classmates to come up with a suitable idea	7	4
Try to solve alone	6	18
Anoher	1 *("try to solve the problem by myself and if I cannot, I will ask for help")*	1 *("look carefully)*

Regarding the careers students envision in 10–15 years, responses varied, but some differences emerged. In Group 1, 12 students chose engineering/programming careers, compared to 5 in Group 2. Conversely, careers in arts/sports were more frequently chosen by Group 2. Students in Group 1 also showed a greater interest in starting a business, mentioning careers in real estate or opening restaurants. For other career options, such as doctor, lawyer, or architect, responses were similar between the groups (13 students in Group 1 and 12 in Group 2).

To assess interest in entrepreneurship, students were asked how much they like the idea of creating something new. None of the students in Group 1 answered *"not at all",* while 4 students in Group 2 did. Most students in Group 1 indicated they liked the idea *"quite a lot",* whereas students in Group 2 were more evenly split between *"a little"* and *"quite a lot".* This suggests that JAR activities positively influence students' interest in creating new things and their attitude toward entrepreneurship.

Regarding qualities important for an entrepreneur, responses were similar across groups. The top three qualities identified were creativity, intelligence, and risk-taking, while ethics, flexibility, and technical/managerial skills were less frequently selected.

Next, students were asked whether they consider JAR projects and programs to contribute to entrepreneurial skill development. Most students in Group 1 (14) stated that JAR significantly contributes, while 9 indicated a small contribution, 4 said not at all, 2 said essential, and 4 were unsure or did not answer. In Group 2, 12 students did not know or did not answer, likely due to lack of familiarity with JAR. Interestingly, 16 students in Group 2 still rated JAR as *"significant"* or *"essential",* possibly associating the program name with entrepreneurship.

Students were also asked which school subjects they consider useful for their future careers. In Group 1, most selected science and mathematics, while in Group 2 the most frequently chosen subjects were mathematics and Romanian language. Group 1 also mentioned biology, physics, and English, whereas Group 2 highlighted sports, English, and physics. These responses suggest that students in Group 1 place particular importance on subjects such as science, mathematics, biology, and physics when thinking about their future careers. In contrast, students in Group 2 consider a broader mix of subjects, including both scientific and language-related disciplines, to be useful. This pattern indicates that students in Group 1 may be more inclined toward career paths that rely heavily on technical and scientific knowledge, including entrepreneurship.

Regarding career counseling services, students in Group 1 mentioned psychological counseling, homeroom lessons, and social education, though some indicated they were unsure or did not consider them useful. In contrast, 21 students in Group 2 did not respond, 4 considered multiple services useful, and the remainder indicated none or were unaware of them. Significant differences exist between the groups in terms of access to and awareness of counseling services. Schools and teachers should emphasize student involvement in counseling activities and present available services for career guidance.

Finally, the study noted that students in Group 1 provided more detailed responses and explanations, reflecting higher self-confidence, whereas students in Group 2 were more reserved and sometimes left questions unanswered.

5. Limitations and further steps

Since this study is a pilot study, the sample size is relatively small, so the results cannot be generalized to the entire population of 8th-grade students in Bucharest or Romania. Additionally, the absence of longitudinal measurement does not allow for the assessment of the long-term effects of participation in JAR activities. Nevertheless, the methodology used provides a solid foundation for the development of future, larger-scale research with an extended sample and a longitudinal design.

Building on the preliminary findings of this pilot study, future phases of the research will transition into a comprehensive, longitudinal investigation focused on the relationship between technical and scientific skills, entrepreneurial qualities, and their measurable impact on the success of technology-based ventures. While the current study provides a foundational exploration of JAR activities, upcoming research will expand this analysis to examine how the combination of strong technical training and specific entrepreneurial traits, such as risk tolerance, innovative problem-solving, and adaptability, influences long-term venture performance.

Furthermore, this expanded research will explicitly integrate Entreprenorial Intentions (EI) as a critical mediator in the development of these competencies, testing the hypothesis that high EI significantly enhances an individual's ability to navigate the complex interpersonal and operational demands inherent in the technology industry. By employing a robust, longitudinal research design that tracks participants over an entire academic cycle and beyond, this project aims to provide empirical evidence on how early exposure to technical, scientific, and entrepreneurial education translates into tangible, long-term professional success within the high-growth technology sector.

6. Discussions and recommendations

Based on the findings of this pilot study, teachers, school leaders, and policymakers are encouraged to promote entrepreneurship education through practical, hands-on activities like those offered by JAR. Teachers should integrate project-based learning, collaborative exercises, and opportunities for

experimentation to develop students' entrepreneurial skills, self-confidence, and problem-solving abilities. School administrators can support these initiatives by offering diverse extracurricular programs, facilitating exchanges of best practices, and creating a school environment that balances learning with student well-being. Policymakers should ensure curricula are student-centered, provide teacher training in innovative teaching methods, and encourage long-term studies to evaluate the impact of entrepreneurial education. These measures collectively can strengthen students' entrepreneurial intentions, prepare them for future careers, and foster a culture of innovation.

7. Conclusions

Thus, the results of the pilot study support the idea that involving students in entrepreneurial activities, such as those carried out through the Junior Achievement Romania (JAR) program, has positive effects on students' attitudes toward entrepreneurship and on the development of skills relevant for pursuing a career in this field. The findings from the pilot study indicate that students who participated in JAR activities show a higher interest in starting a business (mentioning aspirations to open a restaurant or work in real estate) as well as a stronger orientation toward technical careers, such as engineering and programming. Moreover, the fact that these students reported seeking additional information and resources before asking for help in difficult situations suggests a higher level of autonomy, self-confidence, and perseverance compared to students who did not participate in the program. Additionally, students in the first group, who participated in JAR activities, consider subjects like mathematics and computer science more relevant for their future careers, highlighting a potential correlation between entrepreneurial education and the appreciation of STEM competencies.

In conclusion, participation in JAR activities contributes to strengthening entrepreneurial intentions, developing transversal skills, and improving career guidance. However, the pilot nature of this research and the small sample size underscore the need for future longitudinal studies with larger samples to validate and deepen these results.

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PHYSICAL SCIENCES PRE-SERVICE TEACHERS' VR-SUPPORTED 5E INSTRUCTIONAL PRACTICES DURING MICROTEACHING OF ELECTRON CONFIGURATION

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Abstract

Teaching concepts that are abstract such as electron configuration remain challenging in Physical Sciences classrooms, particularly for pre-service teachers who are still developing their pedagogical and technological competencies. The integration of technology with inquiry-based teaching presents opportunities to support visualisation and strengthen instructional practice. This paper reports the findings of a qualitative case study exploring Physical Sciences pre-service teacher's implementation of a VR-enhanced 5E Instructional Model of Inquiry when teaching electron configuration during microteaching. The study focused on three Physical Sciences Post-Graduate Certificate (PGCE) pre-service teachers that were purposively selected from a South African university. The data was collected using lesson plans, non-participant classroom observations, semi-structured interviews, and stimulated-recall reflections. The findings from the lesson plans and semi-structured interviews indicated that pre-service teachers showed willingness to integrate VR and 5E Instructional Model during their teaching. VR was found to be effective as it promoted learner engagement, visualisation of abstract atomic structures, allowed the exploration and promoted the explanation during microteaching sessions and assisted in grasping the concept that is abstract. Challenges were identified during the implementation of the VR-enhanced 5E Instructional Model during micro-teaching such as limited instructional time allocated per pre-service teacher were not enough, technical difficulties due to lack of training, varying levels of confidence in the use of the VR tool from the pre-service teachers, and difficulties in coherently balancing the integration of all phases of the 5E Instructional Model while also implementing the VR tool. Despite these challenges being raised, the pre-service teachers also reported positive teaching experiences and recognised VR as a valuable tool for supporting inquiry-based teaching in science classrooms. The study recommends the purposeful inclusion of VR-supported inquiry approaches within teacher education programmes. Furthermore, opportunities for VR-based microteaching should be expanded to better prepare PGCE pre-service teachers for real classroom contexts and to strengthen their ability to implement inquiry-based instructional practices in Physical Sciences.

Keywords: *5E Instructional Model,* electron configuration, inquiry-based teaching, Physical Sciences, *Virtual Reality.*

1. Introduction

Globally, the use of innovative technologies, particularly Virtual Reality (VR) is transforming the way science subject is taught by creating immersive learning environments that support conceptual understanding. Virtual Reality is implemented by a combination of technologies that are used to visualize and provide interaction with a virtual environment. These environments often depict three-dimensional space which may be realistic or imaginary, macroscopic or microscopic and based on realistic physical laws of dynamics, or on imaginary dynamics. In the education sector, commonly used VR technologies include immersive head-mounted displays (e.g., Oculus devices), desktop-based simulations, and mobile VR applications, which allow learners to interact with three-dimensional representations of scientific concepts in real time (Mojsoska, 2024). These technologies are increasingly adopted because they promote active learning, visualisation, and learner engagement, particularly in topics that are not easily observable in real-life contexts. However, challenges such as high implementation costs, limited access to resources, technical difficulties, and insufficient teacher training continue to hinder its widespread adoption in classroom practice. Electron configuration is a foundational concept in chemistry that explains how the atoms and molecules behave and as the results it is important for the learners to grasp this content. This topic is abstract because of its nature that stems from its focus on submicroscopic particles and symbolic

representations that cannot be directly observed, and they require the learners to mentally connect macroscopic, symbolic, and particulate levels of chemistry; this complexity has been shown to contribute to learning difficulties among learners (Salehzadeh, 2016). In the South African context, studies have further reported that learners struggle particularly with transitioning between these levels of representation, which negatively affects their conceptual understanding of atomic structure and related topics. One of the core difficulties lies in the fact that electron configuration requires the learners to simultaneously understand and integrate the content knowledge across three representational levels in Physical Sciences: the macroscopic (observable phenomena), the sub microscopic (particles and structures at atomic level), and the symbolic (chemical symbols and equations) (Keiner, 2020). According to Dorris (2022), learners struggle with chemistry as part of the Physical Sciences because it operates on three levels and it requires the macroscopic, sub microscopic, and symbolic and it requires the learners to be abstract thinkers. The VR visuals act as cognitive instruments that enable learners to express their conceptual comprehension with assistance from educators who provide support for their explanations. The integration between VR and the 5E model not only improves learners' understanding but also caters to various cognitive styles and learning speeds. Mojsoska (2024) states that the integration of VR with inquiry-based techniques enhances student engagement and understanding in STEM areas. Moreover, incorporating VR into 5E instructional model of inquiry equips pre-service educators with a cutting-edge teaching toolkit that readies them for tech-enriched classrooms. The 5E instructional model of inquiry offers a dependable structure, ensuring that VR is integrated with learning outcomes rather than being used independently. Hite (2022) contends that this alignment is essential to guarantee that digital tools effectively aid in mastering content instead of serving as distractions. The South African Curriculum and Assessment Policy Statement (CAPS), which is the national policy framework that guides the teaching and learning of Physical Sciences for Grade 10-12, explicitly promotes inquiry-based learning by emphasising the development of scientific investigation skills, critical thinking, and active learner engagement in the construction of knowledge (DBE, 2011), and that prepares the learners for the 21st century. These investigative skills are essential for understanding abstract scientific ideas like electron configuration, which numerous students struggle with because of its microscopic and theoretical aspects (Mavhunga, 2013). To address these challenges, Virtual Reality (VR) technologies are becoming increasingly popular in science education to connect abstract concepts with experiential learning.

2. Aims and objectives

Despite the growth in the global research about the effectiveness of Virtual Reality (VR) and 5E Instructional model of inquiry, most researchers have largely focused on learners' outcomes rather than on teachers' pedagogical practices and experiences. Furthermore, limited research within the South African context has explored how Physical Sciences pre-service teachers implement VR-enhanced inquiry-based approaches, particularly when teaching complex topics such as electron configuration during microteaching. As such, there remains a gap in understanding both the implementation processes and the experiences of pre-service teachers using a VR-enhanced 5E instructional model. As the results, this study aims to investigate Physical Sciences pre-service teachers' implementation of the VR-enhanced 5E instructional model of inquiry when teaching electron configuration during microteaching.

The following research questions were posed to guide the inquiry:

- What are Physical Sciences pre-service teachers' experiences when teaching electron configuration using the VR-enhanced 5E instructional model of inquiry during microteaching?
- How do Physical Sciences pre-service teachers implement the VR-enhanced 5E instructional model of inquiry when teaching electron configuration during microteaching?

In addressing these research questions, a qualitative case study approach was employed, in which four Physical Sciences pre-service teachers were purposively selected to participate in the study. These participants were selected based on their engagement in microteaching and their exposure to the VR-enhanced 5E instructional model.

The objectives of the study were to:

- Document Physical Sciences pre-service teachers' experiences when teaching electron configuration using the VR-enhanced 5E instructional model of inquiry during microteaching.
- Investigate Physical Sciences pre-service teachers' implementation of the VR-enhanced 5E instructional model of inquiry when teaching electron configuration during microteaching.

3. Research design & methodology

This study adopts a qualitative research methodology, which is appropriate for exploring in-depth insights, contextual understandings, and the meaning individuals or groups ascribe to a social or educational

phenomenon (Patton, 2022). The qualitative case study design has been specifically selected to guide the research, it enables an in-depth, contextualised understanding of how pre-service Physical Sciences teachers implement the VR-enhanced 5E instructional model during microteaching. Since this study investigates both the experiences and instructional strategies of a small group of participants within the structured setting of microteaching, a case study approach allows for the rich collection of descriptive data. Furthermore, the qualitative nature of the study aligns with the exploratory focus on participants' meanings, perceptions, and practices, which are best captured through open-ended, interpretative methods (Creswell, 2018). This design supports the study's aim of producing insights that are not generalisable in the statistical sense, but transferable to similar teacher education contexts.

4. Data collection

Participants of this study included pre-service teachers' pseudonyms as PGCET1, PGCET2, PGCET3 from one of the institutions in South Africa in Gauteng province. These pre-service teachers already had a minimum of 1 existing degree as the PGCE in Physical Sciences degree requires NQF level 7 in the science degree. To generate in-depth and context-rich data, this study used multiple data collection tools aligned with qualitative research and we used in four stages, namely: lesson plans (document analysis), stimulated recall reflections (video-based reflection sessions), semi-structured interviews, and non-participant lesson observations. The collected data provided insights into Physical Sciences pre-service teachers' 5E instructional model of inquiry practices during micro-teaching in a VR environment. The data was collected using 4 stages to ensure consistency with the data. During stage 1 the lesson plans were collected and analysed as they are authentic blueprints of how the pre-service teachers intend to teach electron configuration using VR-enhanced 5E instructional model of inquiry. In stage 2, the non-participant observation was selected so that the researcher can document detailed field notes during the pre-service teachers' microteaching lessons. In stage 3, Stimulated Recall Reflections (SRR) were conducted immediately after the microteaching sessions using video recordings to prompt participants to reflect on their instructional decisions, lesson delivery, and classroom interactions. In stage 4, the researcher conducted semi-structured interviews thereafter to explore participants' broader experiences of teaching with VR, including the usability of the application and their competence in implementing the 5E inquiry model.

5. Data analysis

The data collected was analysed using an inductive thematic approach involving repeated readings of observation notes, transcripts from stimulated recall reflections conducted after each micro-lesson, interview transcripts, and lesson plan artefacts submitted prior to microteaching. Initial codes were generated based on recurring patterns in participants' actions (e.g., "analogy to orbitals"), teacher intentions (e.g., "engage via scenario"), technical events (e.g., "controller error"). These codes were then clustered into broader themes that naturally aligned with the phases of the 5E Instructional Model of Inquiry. Additional cross-cutting themes such as technical competence, teacher role shifts, and assessment challenges also emerged during the analysis. To ensure trustworthiness, triangulation was applied across data sources.

6. Results

The data sources encompass by the structured lesson plans, non-participants observation notes taken by the researcher during the micro teaching, stimulated-recall reflections by the pre-service teacher immediately after their micro-teaching and the semi-structured interviews conducted via MS Teams with each pre-service teacher at their own convenient time. The findings from this study are reported phase-by-phase using the following phases: Engage, Explore, Explain, Elaborate and Evaluate.

6.1. Engage

Engagement strategies were intentionally chosen by the pre-service teachers in their introductions and aligned to different pedagogical aims based on what the pre-service teacher has planned for their micro-teaching: Teacher 1 emphasized analogical bridging by using our everyday experiences, which helps to grasp the learners attentions and related such daily experiences with the concept of electron configuration, and Teacher 2 used diagnostic questioning which assist a lot to check on the learners prior knowledge and assist in building the concept that is abstract with something that the learners they can easily relates with, and Teacher 3 aimed to build familiarity with the medium tool of instruction which is Virtual Reality (VR) itself. These approaches are consistent with 5E theory where Engage triggers curiosity and

reveals prior conceptions (Barufaldi, 2002). This phase is more centered as it stimulates motivation which creates the desire to learn more about the topic. The data show that, in practice, VR was not necessarily the primary engagement device at the beginning of the lesson, but the pre-service teachers preferred the short verbal hooks or analogies before full immersion with the device.

6.2. Explore

The Explore phase emerged as the stage with the strongest affordances of VR, as it required learners to actively engage in hands-on construction of atomic models. This kept the lesson progressing as the learners got immediate visual feedback when the atom gets to be made as well as the electron configuration for that atom and that promoted multimodal interaction. This phase is also learner-centered and incorporates active exploration within the VR tool. The table below will summaries the pre-services teacher's experiences of how they implemented the VR when teaching the electron configuration in the exploration phase of the 5E Instructional Model.

Table 1. Explore phase: summary across teachers (observations, reflections, interviews).

Indicator	Teacher 1	Teacher 2	Teacher 3
1. **Planned VR atom creation** *(lesson plan)*	Yes	Yes	Yes
2. **Learners given the opportunity for hands-on VR time.**	*Yes, however they were monitored.*	*Yes, however they were monitored*	*Yes, but their time was very less because of the technical issues that they encountered.*
3. **Pre-service teacher well orientated about VR.**	*Competent*	*Still a novice but proficient*	*Struggling and resulted in frequent resets and restart*
4. **The reflection about the effectiveness of implementing the VR tool.**	Positive about the Implementation and promoted a lot of visualisations	Positive and this motivated a lot of learners and kept them engaged and excited	Mixed as the tool was unfamiliar which led to the hindering of the flow
5. **The** *sample* **of their interview.**	*"Using this tool is rewarding as in most of the times we are using our devices, and it get easy to use it…" says Teacher 1*	*"Learners were captivated" says Teacher 2*	*"I occasionally pressed wrong commands… had to reset" says Teacher 3*

6.3. Explain

The explanation phase is an essential, minds-on part of the 5E lesson. The explanation phase enabled the learners to describe their understanding and pose questions about the concepts they have been exploring. New questions were generated, and they promoted the discussion in the classroom and that kept the classroom engaged. This phase was a natural fit for the use of the VR tool because the visual, dynamic representations facilitated teacher-led conceptual clarification as the learners were able to inquire about how the orbitals got filled and why the atom were not created.

6.4. Elaborate

During this phase the teachers extended the learning by asking their learners to apply orbital rules to new atoms and asked them to reflect on the shape, and to explain if the electron configuration has any factor on it and PGCET3 explained how such atoms can help us in real-life. Elaboration occurred as the pre-service teacher designed tasks that required learners to apply concepts, for example producing electron configurations using unfamiliar elements. However, the data collected suggested that elaboration was sometimes superficial or constrained by practicalities due to the limited time using the googles and the availability of the VR device.

6.5. Evaluate

During the Evaluate phase, the pre-service teachers attempted to assess their lesson objectives per their lesson planning if they had been achieved. This was done by asking learners to construct atoms and present their electron configurations using the VR model without being assisted. The learners manipulated virtual atomic models, placing electrons into orbitals, and verbally explaining their configurations while the teacher was observing and asking follow-up questions based on their atomic structures. However, evaluation emerged as the weakest and the phase that challenged both teachers and learners, and all three pre-service teachers agreed on each other. Observations revealed that, although learners were able to complete the tasks, their responses were largely descriptive, and their focus was on what they visually observed in the VR simulation rather than demonstrating deeper conceptual understanding of the electron-configuration. This was further confirmed during post-lesson interviews, where pre-service teachers reflected on the difficulty of content grasping, conceptually grounded explanations from learners.

7. Discussion

The findings of this study show that pre-service teachers experienced VR as both an exciting and challenging instructional tool when implementing the 5E model to teach electron configuration. Participants expressed enthusiasm about the immersive nature of the tool, with one noting that *"the VR made it easier to visualise something I usually struggle to explain on the board"* (PGCET1). However, this excitement was accompanied by notable challenges, particularly as it was their first time interacting with VR in a teaching context. For instance, another participant reflected that *"I was not confident at first because I did not know how to fully integrate the VR with my teaching strategy"* (PGCET2). This lack of confidence can be attributed to their limited exposure to pedagogical strategies during their PGCE training, as highlighted by a participant who stated that *"we were not really trained on how to use such technologies in our teaching"* (PGCET3). Through reflections and interviews, participants consistently described VR as highly engaging, offering learners the ability to visualise abstract atomic structures in three dimensions which are difficult with traditional teaching and learning tools. PGCET3 noted that VR made them feel as though they had "stepped into a different world," highlighting its immersive and transformative potential. This comment resonated with what was once said by the researcher Rammnarain's (2021) argument that inquiry-based learning is strengthened when the learners they can manipulate concrete representations of abstract content to something that can be easily understood. Another critical finding relates to the Evaluate phase of the 5E Instructional Model, which all three pre-service teachers described as the most difficult stage to implement with VR. Their challenges can be explained by the limited assessment literacy since before they were enrolled for the different degree and they have not even yet finished a year in the education course. The participants were still learning how to move beyond descriptive questioning toward eliciting deeper conceptual understanding in the classroom.

8. Conclusion and recommendations

In conclusion, this study highlighted the transformative potential of the VR-enhanced 5E instructional model in supporting the pre-service Physical Sciences teachers to integrate the inquiry-based learning when teaching one of the abstract concepts of electron configuration. The PGCE pre-service teachers should be enrolled in the modules that will provide them with opportunities to practice lesson planning, microteaching, and reflection while receiving feedback on both pedagogical strategies and assessment practices as that will prepare them for the practical classroom. In addition, the novice teachers must pair with more experienced physical science teachers as that could help to build confidence in navigating the Evaluate phase of the 5E Instructional Model, which was identified as the phase that the participants struggled in. Addressing these gaps through professional development, curriculum guidance, and practical support can strengthen pre-service teachers' confidence and pedagogical effectiveness so that as they become in-service teacher's they will be more than enough fit to shape the world.

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INNOVATIVE TEACHING OF RENEWABLE ENERGY TECHNOLOGIES THROUGH REAL-TIME DATA MONITORING OF MICROGRIDS

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Abstract

This paper presents a virtual laboratory designed to support remote instruction on renewable energy–based microgrids within undergraduate Electrical Engineering programs. The system comprises four 100 Wp photovoltaic panels and a 400 W wind turbine generator. Microgrid data are collected through dedicated acquisition devices and stored in a time-series–optimized database. A Telegram application programming interface (API) enables access to microgrid and weather station data. Student feedback, gathered through a questionnaire, indicates high satisfaction with the virtual laboratory, with an average rating of approximately 4.5 out of 5. Participants strongly agreed that the platform enhanced academic skills and supported the achievement of program learning objectives. Overall, the virtual laboratory significantly improved students' understanding of renewable energy microgrids and constitutes an effective complement to traditional in-person laboratory instruction.

Keywords: *Interactive learning, remote access, telegram bot, graphical user interface, virtual laboratory.*

1. Introduction

The impacts of climate change are increasingly evident, leading governments worldwide to promote ambitious strategies to achieve carbon neutrality (IEA, 2022). A representative example is the European Green Deal, which aims to reach climate neutrality by 2050 (European Commission, 2023). Achieving this goal requires the large-scale integration of renewable energy sources, particularly solar and wind, together with the electrification of sectors such as transportation.

The high penetration of renewable generation introduces significant challenges to power system operation due to its variability and uncertainty. To address these issues, advanced solutions such as energy storage, demand response, and coordinated energy management are required. In this context, microgrids have emerged as a promising framework, enabling the efficient integration of distributed energy resources while improving system reliability and flexibility (NREL, 2023).

In parallel, the growing relevance of sustainability has increased the importance of renewable energy education within engineering programs. Laboratory-based learning remains essential, but access to conventional laboratories is often constrained. Recent advances in digital technologies have therefore promoted the adoption of virtual and remote laboratories, which allow students to perform practical experiments through Internet-based platforms, improving accessibility, safety, and resource efficiency (Sapriati et al., 2023).

Despite their widespread use in electrical engineering education, the application of virtual laboratories to renewable-energy-based microgrids remains limited. Accordingly, this paper presents an educational experience based on a real-time monitored microgrid for the remote teaching of renewable energy technologies in undergraduate electrical engineering programs, highlighting its structure, implementation, and educational benefits.

2. Microgrid description

As shown in Figure 1, the microgrid integrates photovoltaic and wind energy sources with battery storage. The photovoltaic (PV) system consists of four 100 Wp panels, while the wind subsystem includes a turbine coupled to a 400 W generator. Energy storage is provided by a lead–acid battery bank with a rated

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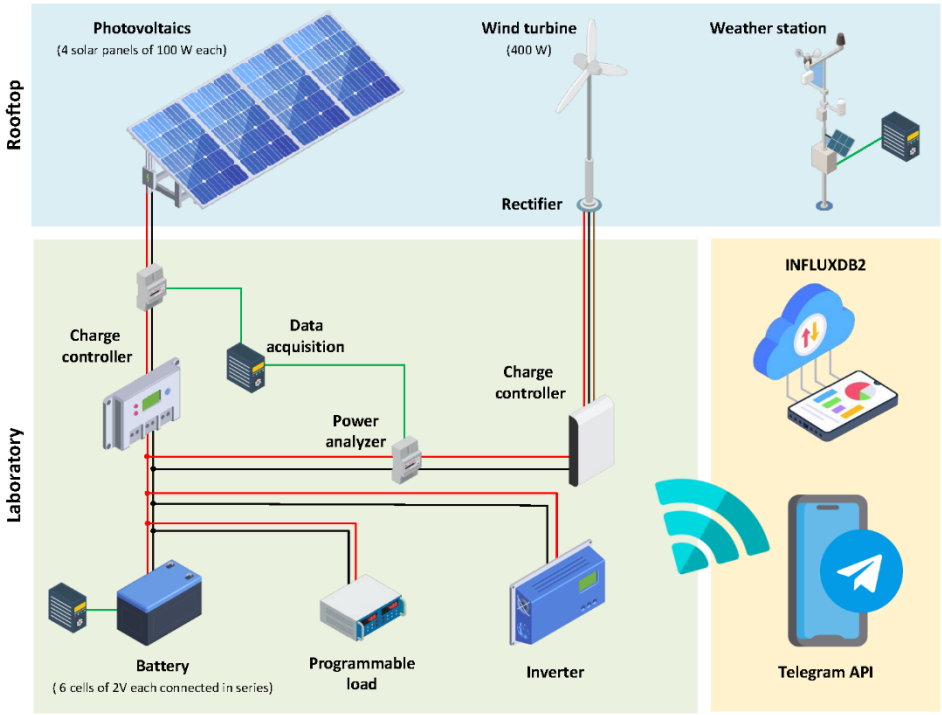
capacity of 431 Ah (C_{100h}). A nearby weather station measures key environmental variables, including temperature, solar irradiance, wind speed and direction, humidity, pressure, and precipitation.

Most of the remaining equipment is installed in the laboratory. The PV panels are connected to a charge controller linked to a series-connected battery bank. The wind generator feeds a rectifier and a dedicated charge controller, enabling safe conversion and regulation of the generated power prior to storage. Both controllers regulate voltage and current to prevent battery overcharging. The stored DC energy can be converted to AC through an inverter, while a programmable DC load allows controlled battery discharge, enabling the emulation of realistic consumption profiles.

Microgrid data acquisition is carried out through multiple devices: the charge controllers provide PV production data, power sensors monitor wind generation, battery communication interfaces supply state-of-charge information, and a datalogger records weather data. All measurements are stored in a time-series database (InfluxDB2), and the collected data can be remotely accessed through a Telegram-based interface.

Figure 1. Schematic diagram of the microgrid.



3. Methodology

The proposed methodology focuses on real-time data acquisition, processing, visualization, and remote interaction with a renewable-energy-based microgrid to support a virtual laboratory environment. Measurements from the wind turbine, photovoltaic system, battery storage, and weather station are collected using a unified data acquisition architecture based on a microcontroller, which aggregates and transmits the information to a personal computer at fixed time intervals.

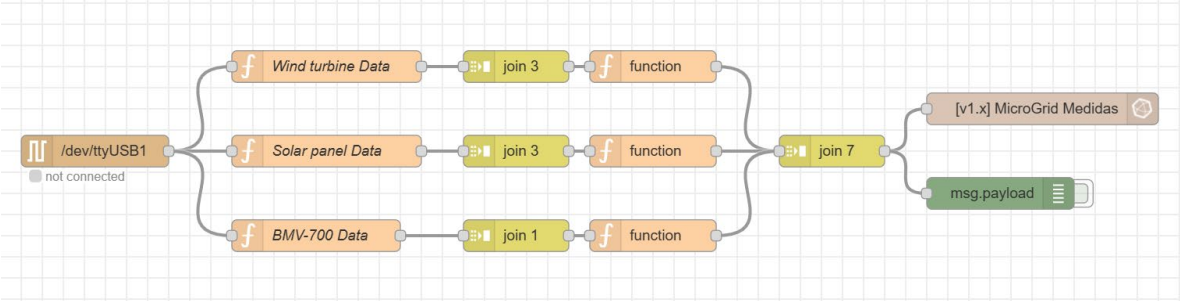
Data processing and storage are carried out using Node-RED and InfluxDB, respectively. Node-RED manages data reception, validation, and formatting, while InfluxDB serves as a time-series database optimized for high-frequency sensor data. As illustrated in Figure 2, the incoming data streams are parsed, combined, and stored in a structured manner, enabling efficient querying and long-term analysis.

For real-time visualization, a graphical user interface is implemented using Grafana. This dashboard allows users to monitor power generation from wind and photovoltaic sources, as well as the battery state of charge, over customizable time ranges. Visual indicators such as time-series plots, bar graphs, and gauges provide an intuitive understanding of system behavior and performance.

To enhance the educational experience, the monitoring platform is complemented by a virtual laboratory composed of a programmable DC electronic load and a messaging-based user interface. The programmable load enables students to emulate realistic consumption profiles and analyze battery response under varying demand conditions. In parallel, a Telegram-based interface allows users to remotely query real-time information on power generation, energy production, battery status, and weather conditions.

Together, these tools provide continuous remote access to the microgrid, fostering interactive, experiment-driven learning in renewable energy education.

Figure 2. Data processing using Node-RED and InfluxDB.

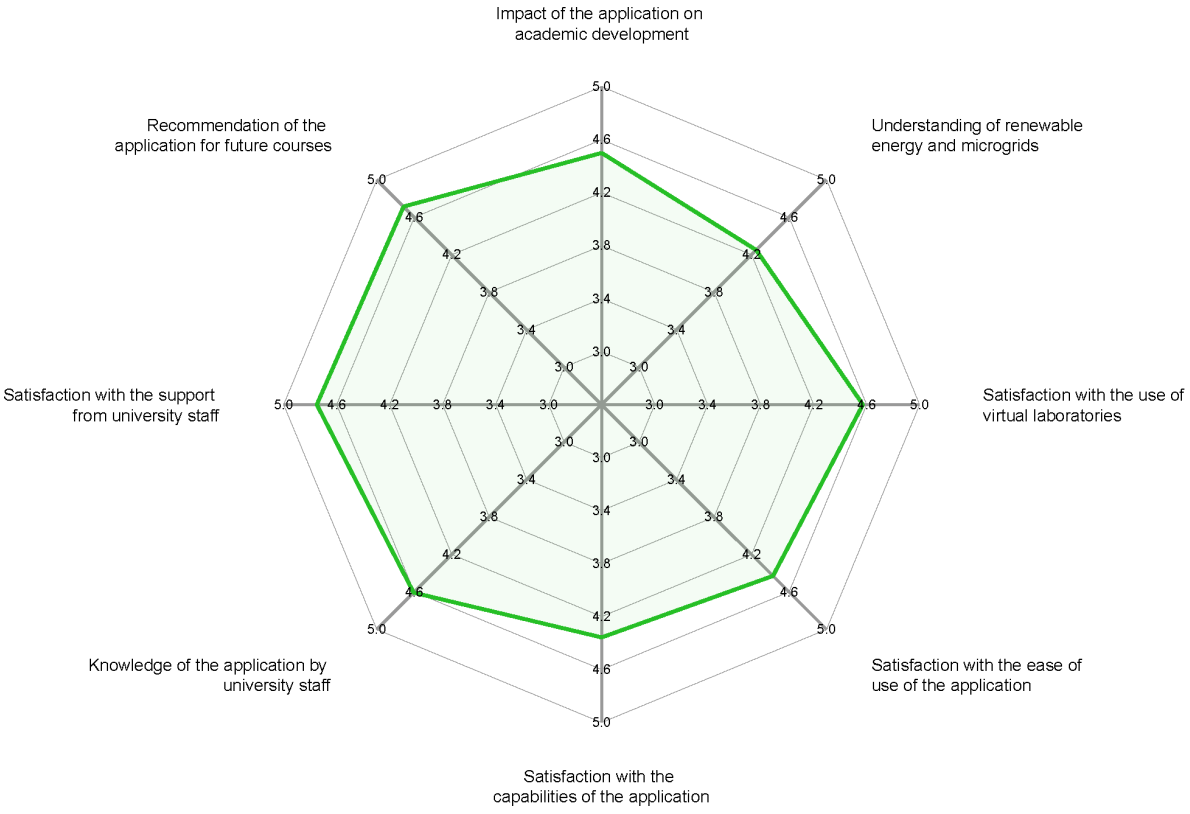


4. Educational benefits and educator's perspective

This section analyzes the educational benefits of the developed virtual laboratory and presents educators' perspectives on its impact on student engagement and skill development in undergraduate electrical engineering programs. Remote laboratories are expected to enhance traditional learning environments by providing additional educational value and practical relevance (Grout, 2017).

To evaluate the educational experience, a questionnaire based on a five-point Likert scale was administered to 28 participants. The survey assessed perceived skill development, alignment with degree objectives, usability, and overall satisfaction. The aggregated results are presented in Figure 3 using a radar plot.

Figure 3. Radar plot of the participant feedback on the questionnaire aimed at assessing various aspects about the educational experience of the developed virtual laboratory.



As shown in Figure 3, the feedback was highly positive, with an overall average score of 4.50 out of 5. Participants strongly agreed that the virtual laboratory effectively supports the development of academic skills, contributes to achieving undergraduate learning objectives, and should be more widely

integrated into engineering curricula. High satisfaction was also reported regarding the system's usability, functionality, and visual design, as well as the preparedness of academic staff to manage such tools.

The virtual laboratory enables students to actively interact with a real microgrid, promoting a deeper understanding of solar and wind energy systems through hands-on experimentation rather than purely theoretical instruction (Grout, 2017). This experiential learning approach enhances knowledge retention and practical competence. From an instructional perspective, the platform allows educators to deliver more engaging content and supports self-regulated learning by providing continuous remote access to real system data (Sapriati et al., 2023). Overall, the virtual laboratory improves accessibility, flexibility, and educational quality, aligning with modern trends in engineering education (Almarshoud, 2011).

5. Conclusions

This paper has investigated the role of virtual laboratories as an effective approach for supporting the remote teaching of microgrids based on renewable energy technologies, with particular emphasis on their design, implementation, and deployment within undergraduate electrical engineering programs. The proposed virtual laboratory represents a flexible and scalable educational resource that complements conventional laboratory-based instruction and addresses several limitations associated with exclusively face-to-face experimental activities.

Unlike traditional laboratory models that depend heavily on physical presence and direct supervision, the developed platform enables continuous remote access to a real microgrid, allowing students to observe, analyze, and interact with renewable energy systems under realistic operating conditions. This approach not only enhances accessibility and inclusiveness but also promotes active and experiential learning, thereby strengthening students' understanding of key concepts related to solar and wind energy integration, energy storage, and system management. As a result, the microgrid-based virtual laboratory contributes to a more comprehensive and practice-oriented educational experience.

Furthermore, the remotely accessible nature of the laboratory supports self-regulated learning and facilitates the adaptation of teaching methodologies to diverse student needs and learning paces. By integrating real-time data monitoring and interactive tools, the platform bridges the gap between theoretical instruction and practical application, fostering higher levels of engagement and motivation. Consequently, the virtual laboratory serves as a valuable pedagogical instrument for modern engineering education, particularly in the context of sustainability-driven curricula.

Future developments of the proposed system may include the integration of additional sensors to expand monitoring capabilities, enhancements to data storage and processing infrastructures, and further refinement of the remote user interface to improve usability and interactivity. Moreover, the incorporation of artificial intelligence and data-driven models for forecasting energy production and system behavior represents a promising direction. Such advancements would not only deepen students' technical understanding but also enable the acquisition of cross-disciplinary competencies in data analytics, predictive modeling, and intelligent energy management, thereby further enriching the educational value of the virtual laboratory.

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NAVIGATING BUSINESS LANGUAGE: PRE-SERVICE TEACHERS' LOTL PRACTICES IN MULTILINGUAL CLASSROOMS

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Abstract

The Language of Teaching and Learning (LoTL) remains a critical mediator of access to curriculum knowledge in multilingual classrooms. In Business Studies, where technical terms and abstract concepts dominate, limited proficiency in the LoTL may constrain student-teachers' ability to explain content and to position themselves confidently as teachers. This paper reports on a qualitative case study that explored how Business Studies student-teachers at the University of Johannesburg experienced language proficiency during school-based teaching practice. The study was informed by Bandura's self-efficacy theory and situated in an interpretivist paradigm. Data were generated through semi-structured one-on-one interviews with three third-year student-teachers specialising in Business Studies. The data were analysed thematically. Two research questions guided the paper: how student-teachers experience language proficiency when implementing the LoTL in multilingual classrooms, and how language proficiency shapes their self-efficacy and confidence during teaching practice. The findings show that English proficiency was viewed as necessary because Business Studies content, notes, and assessment expectations are largely delivered in English. However, English alone did not resolve the problem of learner understanding. Participants reported that learners often lost the meaning of key concepts and business terminology, which required student-teachers to simplify explanations, use learners' home languages for examples, and draw on informal translation support. The findings also reveal that confidence was not only a language issue but also a content and context issue. Participants became more confident when they understood Business Studies terminology, could ask questions in supportive spaces, and could make language choices that matched learner needs. The study concludes that teacher education should strengthen the disciplinary language of academic English and Business Studies while also preparing student-teachers to use principled multilingual strategies in classrooms.

Keywords: *Business Studies, language proficiency, LoTL, multilingual classrooms, self-efficacy.*

1. Introduction

Language proficiency is an essential aspect of education because teaching depends on language to introduce concepts, explain examples, ask questions, give feedback and assess understanding. In multilingual classrooms, this becomes more complex because the official Language of Teaching and Learning (LoTL) may not be the language through which all learners make meaning. The South African Business Studies Curriculum and Assessment Policy Statement (CAPS) sets out subject content and assessment requirements for Grades 10-12, but the effective teaching of that content still depends on how teachers communicate concepts to learners (Department of Basic Education (DBE), 2011).

Business Studies is particularly language-sensitive because learners are expected to understand content through subject-specific terms, business examples, definitions and examination phrasing. Academic language is not simply ordinary conversation; it is the language through which school knowledge is organised, explained and assessed (Schleppegrell, 2012). For student-teachers, the challenge is therefore not only to know English generally, but also to use Business Studies language clearly enough for learners who come from different linguistic backgrounds. Existing work on Business Studies has shown that language can become a barrier when learners and teachers struggle to attach meaning to the concepts used in the subject (Mudaly & Singh, 2018).

The issue is also linked to teacher preparation. Linguistically responsive teacher education argues that teachers should understand learners' linguistic resources and use them to support learning, rather than treating multilingualism solely as a problem (Lucas & Villegas, 2011). At the same time, English remains important in many South African schools and university contexts because it is used in curriculum documents, textbooks, notes, assessment practices and professional communication. This creates tension for Business Studies student-teachers: they need to strengthen their academic English while also drawing on learners' home languages as resources for understanding.

This paper focuses on the experiences of three Business Studies student-teachers at the University of Johannesburg during their initial teacher education teaching practices experiences. It does not compare student-teacher and learner perceptions because learners were not interviewed. Instead, the paper presents a small but focused case study of how student-teachers themselves made sense of language proficiency, LoTL implementation and confidence in multilingual classrooms. The contribution of the paper lies in showing how the disciplinary language, code-switching, informal translation support, and self-efficacy intersect in the early professional development of student-teachers.

The paper addresses the following refined research questions: 1. How do Business Studies student-teachers experience language proficiency when implementing the LoTL in multilingual classrooms? 2. How does language proficiency shape Business Studies student-teachers' self-efficacy and confidence during teaching practice?

2. Literature review and theoretical framework

Language proficiency is strongly connected to access, participation and the quality of classroom communication. UNESCO (2003) argues that education in multilingual contexts requires careful attention to local languages and wider languages of communication. In this study, this balance is evident in participants' accounts where English was treated as necessary for Business Studies, but learners' home languages were also needed to clarify meaning when English-only explanations did not suffice.

In teacher education, academic language proficiency is particularly important because teachers are expected to model and teach the language used in school subjects. Van der Merwe (2018) shows that teacher education students require well-developed academic language proficiency to engage successfully with academic and professional tasks. For Business Studies student-teachers, this includes reading notes and textbooks, explaining definitions, marking learners' work and using the correct business terminology. Schleppegrell (2012) similarly positions academic language as central to teaching and learning because subjects are built through particular ways of using language.

The Business Studies classroom is, therefore, a useful site for examining LoTL practices. Mudaly and Singh (2018) note that language can operate as a barrier in the teaching and learning of Business Studies. This is consistent with the participants' repeated references to keywords, concepts, and terminology, as well as the difficulty of making Business Studies language meaningful to learners. The problem is not only whether a teacher speaks English, but whether the teacher can connect English, disciplinary vocabulary and learners' linguistic resources in a way that supports understanding.

The study is also framed by Bandura's self-efficacy theory. Bandura (1982) explains self-efficacy as people's beliefs about their capability to organise and perform actions required for particular tasks. In teaching practice, self-efficacy is linked to how student-teachers judge their ability to stand in front of a class, explain content, answer questions and manage classroom uncertainty. Iroegbu (2015) notes that self-efficacy influences effort, persistence, and performance, while Olivier et al. (2019) show that self-efficacy is associated with engagement and achievement. In the present study, self-efficacy is used to understand how language proficiency and content knowledge affect student-teachers' confidence and sense of professional legitimacy.

3. Research methodology

This study adopted an interpretivist qualitative approach to understand how student-teachers interpreted their experiences of language proficiency and LoTL implementation. A qualitative case study design was appropriate because the study focused on a small group of participants within a specific teacher education context (Yin, 2018). The purpose was not to generalise statistically, but to provide a detailed account of how three Business Studies student-teachers experienced language in multilingual classrooms.

The study site was the University of Johannesburg. Participants were third-year student-teachers in the Methodology and Practicum programme for Business Studies. All three participants had between one and three years of integrated learning or practical teaching experience. The participant profile is shown in Table 1. Pseudonyms are used to protect participants' identities.

Table 1. Participant profile.

Participant	Teaching experience	Gender	Subject specialisation
Participant A	1-3 years of integrated learning/practicals	Female	Business Studies; Economic Management Sciences; English First Additional Language
Participant B	1-3 years of integrated learning/practicals	Female	Business Studies; Economic Management Sciences; English Home Language
Participant C	1-3 years of integrated learning/practicals	Female	Business Studies; Economic Management Sciences; English First Additional Language

Data was generated through semi-structured one-on-one interviews. The interview questions focused on English proficiency, LoTL practices, challenges in teaching Business Studies, code-switching, and the relationship between language proficiency and confidence. The interviews allowed participants to describe their experiences during practical teaching, including the language choices they made when learners did not understand English explanations.

Data were analysed thematically. Following the logic of thematic analysis, the interview data were read closely, recurring ideas were coded, and related codes were grouped into themes (Braun & Clarke, 2006). The themes were then refined to align with the two research questions. The analysis remained close to the participants' own words, and direct extracts are used in the findings to show how the interpretation was developed. Ethical care was taken by using pseudonyms and avoiding identifying details about participants or schools.

4. Research findings

Two main themes emerged from the analysis. The first concerns how participants experienced language proficiency when implementing LoTL in Business Studies classrooms. The second concerns how language proficiency, content knowledge and classroom context shaped their self-efficacy and confidence. The findings are presented as situated insights from three student-teachers rather than as claims about all Business Studies student-teachers.

4.1. Language proficiency and LoTL implementation in business studies

The first finding is that participants regarded English proficiency as necessary but not sufficient for successful Business Studies teaching in multilingual classrooms. Participant A viewed English as the common classroom language that could reduce confusion when learners came from different linguistic backgrounds: *"You need to know your English so that you should be able to explain almost everything, like 90% of your content in English, so that everyone will understand it." (Participant A)*

This response shows that English was understood as a shared LoTL for Business Studies. However, the same participant also explained that English alone was not always enough. She argued that student-teachers should also be multilingual where possible because learners' home languages can make examples and explanations easier to understand. Her own code-switching was mainly used when making examples, while she tried to keep the main content in English.

Participant B offered a more contextual view, stating that the level of English proficiency required depends on the school, the area, and learners' language backgrounds. She indicated that Business Studies notes, textbooks and departmental resources were usually encountered in English. For this reason, reading and writing in English were important for preparing notes, reading subject material and marking learner work. However, she also described a classroom in which many learners did not understand certain English concepts. In that situation, the expectation to provide notes and explanations in learners' languages became difficult because there were several languages in the class.

A key point from Participant B is that informal translation support was not presented as a formal university strategy. It appeared as an organic response to a classroom problem during teaching practice. She explained that she had to ask friends and someone who could translate so she could summarise what she wanted learners to know in a language they could understand. This shows peer translation as a survival strategy that emerged from the demands of multilingual teaching rather than as a planned part of the practicum.

The challenge became sharper when Business Studies activities were presented in English only. Participant B described using a game to teach Business Studies content, but the learners who were not from English-speaking homes did not understand the activity as expected: *"Even though the work was in the notes, I feel like they lose the meaning of certain concepts and key words." (Participant B)*

This extract highlights the disciplinary nature of the language problem. The learners had notes, but the concepts and keywords remained unclear. For Business Studies, therefore, the LoTL challenge is not

only about speaking English fluently. It also involves explaining business terminology, making examples relevant and checking whether learners have attached the correct meaning to the concepts.

Participant C also linked LoTL implementation to examples and learner understanding. She reported that she used the native language when explaining examples so that learners could understand better: *"I was explaining the examples in the native language, so that they could understand better." (Participant C)*

Across the three interviews, the data show a pattern: English remained important for the curriculum and for Business Studies content, but participants negotiated the LoTL through code-switching, simplified explanations and informal translation when English-only explanations limited learner participation. These practices were not used to replace English completely. Instead, they were used to support meaning-making where learners' understanding of Business Studies terms was uncertain.

4.2. Language proficiency, confidence and self-efficacy

The second finding is that language proficiency shaped student-teachers' self-efficacy, but only in combination with content knowledge and classroom context. Participant A did not see confidence as a language matter only. She explained that knowing the content was also important because a teacher who knows the content can explain it more effectively. When asked whether language proficiency influenced confidence, she responded that it was "50/50". This suggests that language and content knowledge worked together in her experience.

Participant A also explained that she had felt less confident when expected to explain content in English to learners who mainly spoke another language. Her preference was to teach in a school where she could code-switch when needed. This shows that confidence was linked to the freedom to make language choices that matched the classroom context. A student-teacher may know the content, but still feel less confident if the expected LoTL does not support communication with learners.

Participant B connected confidence to understanding what one is reading, saying and teaching. She stated that a teacher feels more competent when the teaching language is understood. At the same time, she described difficulty when learners asked questions in a different language or switched between English and their home language. This made it difficult for her to respond with confidence, even though she was an English Home Language speaker. Her account is important because it shows that being confident in English does not remove all LoTL challenges in a multilingual Business Studies classroom.

Participant C's account showed the strongest connection between content, terminology and confidence. She had not done Business Studies at school and therefore experienced both content and language pressure during teaching practice. She described an incident where a mentor gave her a textbook and expected her to teach on the first day: *"I do not have any confidence in class. I just asked the guys how you are trying to explain, but honestly, I couldn't. I was embarrassed." (Participant C)*

This example shows how low confidence was produced by a combination of limited familiarity with the content, uncertainty about terminology, and the pressure to perform as a teacher. Participant C later explained that she needed to know the content and receive support so that she could teach comfortably. She also reported that it was easier to ask questions in smaller classes than in larger ones, suggesting that supportive spaces can help student-teachers build confidence.

Participant C further reflected on how the language of Business Studies became easier over time. She explained that first-year Business Management was difficult because of the terminology, and that she had to go back and translate many of the words. However, she became more confident as her English language skills and understanding of business terminology improved. This finding supports the view that self-efficacy can develop through repeated exposure, support and improved mastery of disciplinary language.

Figure 1. Language proficiency, LoTL implementation and self-efficacy pathway emerging from the data.

Disciplinary language demands: Business Studies terminology, English notes, and curriculum and assessment expectations	→	Negotiated LoTL practices: English explanation, code-switching for examples, simplified explanations, and informal translation support	→	Self-efficacy outcomes: confidence, comfort, participation and professional legitimacy during teaching practice

5. Discussion

The findings show that the relationship between language proficiency and Business Studies teaching is more complex than a simple English versus home language debate. Participants recognised the importance of English because the subject uses English notes, terminology, and assessment practices. This finding is consistent with the view that academic and disciplinary language are central to teaching and learning (Schleppegrell, 2012; Van der Merwe, 2018). However, participants' experiences show that English proficiency alone does not guarantee understanding in multilingual classrooms. The data support a balanced approach. Student-teachers need strong academic English to read, write, explain, and assess

Business Studies content. They also need linguistically responsive strategies that allow learners' home languages to be used as resources when concepts and keywords lose meaning. This aligns with Lucas and Villegas's (2011) view that teacher preparation should help teachers respond to linguistic diversity. In this study, code-switching was used for examples and clarification, not as a replacement for English, suggesting that principled code-switching can bridge curriculum language and learner understanding.

The self-efficacy findings are also significant. Bandura's (1982) theory helps explain how language proficiency affects confidence, effort, and classroom participation. However, the interviews show that self-efficacy was not shaped solely by language. Content knowledge, familiarity with Business Studies terminology, mentor support, class size, and the ability to ask questions also influenced confidence. For Participant C, the problem was not only speaking English but also not knowing the content well enough to explain it confidently. For Participant B, the challenge was not low English proficiency but learners' language diversity and the difficulty of responding when learners switched languages. For Participant A, confidence depended partly on being allowed to code-switch, where English-only teaching did not work well. Figure 1 summarises the pathway that emerged from the data: student-teachers faced disciplinary language demands, negotiated the LoTL through English explanations, code-switching, simplification, and informal translation, and these practices influenced confidence and professional legitimacy.

6. Conclusion and recommendations

This paper explored how three Business Studies student-teachers experienced language proficiency when implementing the LoTL in multilingual classrooms, and how language proficiency shaped their self-efficacy during teaching practice. The findings indicate that student-teachers need English proficiency, disciplinary language support, and practical strategies for teaching learners who do not always understand Business Studies concepts when explanations are given only in English. The study therefore argues for a balanced approach that strengthens academic English while mobilising multilingual repertoires to support learner understanding.

Three recommendations emerge. First, Business Studies methodology modules should explicitly teach academic language, including key concepts, definitions, examination phrasing, and common learner misunderstandings. Second, teaching practice mentoring should include structured feedback on LoTL decisions, especially when student-teachers use code-switching, examples, or informal translation support. Third, teacher education programmes should develop shared glossaries and bilingual exemplars for core Business Studies terms, enabling student-teachers to prepare principled multilingual resources rather than rely on last-minute translation. The study is limited by its small sample of three student-teachers and the absence of learner interviews. The findings should therefore be read as depth-based insights rather than generalizations about all Business Studies classrooms. Future research could include learners' perspectives and compare how student-teachers' language choices are experienced across different school contexts.

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INTEGRATING ARTIFICIAL INTELLIGENCE IN STRATEGIC DESIGN EDUCATION: EMPIRICAL EVIDENCE FROM DESIGN COURSES

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Abstract

The rapid adoption of AI tools is transforming educational practices, particularly in Strategic Design, which demand complex problem framing and strategic decision-making. This study examines AI's impact on Strategic Design education through a course experiment where students developed strategic directions for real companies via established process phases. A post-course survey (N=50) assessed AI usage and perceived utility across phases, combining quantitative (Likert-scale) and qualitative measures. Results reveal AI's highest utility in early analytical phases (company description, market/competitor analysis, trend exploration, target identification), where it accelerates information retrieval and synthesis as a cognitive amplifier, without supplanting interpretive roles. Utility declines in generative phases (opportunity definition, scenario construction, selection), where human judgment, critical thinking, and strategic framing remain essential. Findings advocate explicit AI literacy, critical evaluation, and metacognitive training in design curricula, repositioning AI as an augmentative resource contingent on students' problem-framing and output-assessment skills. This approach cultivates designers balancing human reasoning with AI support in complex strategic processes.

Keywords: *Artificial Intelligence, strategic design, critical thinking, human–AI collaboration, design education.*

1. Introduction and theoretical background

Today's rapidly evolving society imposes unprecedented uncertainty and complexity on students preparing to enter the professional world. The modern workplace demands responses to ambiguous, multidimensional challenges that exceed the scope of individual expertise or monodisciplinary approaches, requiring instead holistic solutions developed through cross-disciplinary teamwork (Carella & Melazzini, 2023; Brassler & Dettmers, 2017; Yusri et al., 2024). Higher education must therefore prioritize cultivating core 21st-century competencies such as critical thinking and problem-solving, effective communication, collaborative capacity, team leadership, and creative innovation, essential for tackling contemporary challenges with both analytical rigor and imaginative insight (Brassler & Dettmers, 2017; Stentoft, 2017; Yusri et al., 2024).

The teaching of Strategic Design in higher education serves as a critical mechanism for equipping students with competencies essential for professional success. This discipline employs design-centered methodologies to formulate corporate strategies, systematically integrating product, service, and communication dimensions to construct organizational identity, competitive positioning, and mission clarity (Bell, 2008). Professionally, Strategic Design generates distinctive strategic outcomes through its inherently multidisciplinary character, functioning as a vital conduit between management practice and creative disciplines (Barrett & Sexton, 2006). Design's core methods sch as rapid prototyping, visual canvases, narrative scenarios and iterative sensemaking empower strategic designers to decode ambiguous, open-ended challenges, identify emergent societal patterns beyond organizational boundaries, and catalyze decisions with enduring impact (Zurlo, 2009; Calabretta et al., 2016). Learning Strategic Design is therefore essential for young designers, as it provides them with a human-centred and future-oriented mindset and enables them to act as a bridge between business and design within organisations, bringing to light opportunities to improve the company's offering.

When discussing education and how it must change to cope with the growing complexity of today's society, it is essential to consider the new role that technologies such as artificial intelligence (AI) are coming to play. AI's pervasive influence is reshaping societal structures across domains, boosting efficiency and intensifying ethical and equity challenges (Sabherwal & Grover, 2024). In healthcare,

governance, and creative sectors, AI automates cognitive labor, enhances predictive capabilities, and reconfigures employment landscapes, potentially displacing roles while exacerbating digital divides (Cai & Huang, 2025). Concurrently, risks of bias, diminished human agency, and socioeconomic polarization demand robust governance frameworks. This social transformation requires education systems to adapt, rethinking how technology influences teaching, learning and skills development.

Educational frameworks must therefore account for technology's transformative influence on pedagogy and learning processes. The widespread adoption of AI tools is fundamentally reshaping instructional practices, particularly within disciplines requiring sophisticated problem framing and anticipatory decision-making, such as Strategic Design. In educational contexts, AI streamlines instructional design and facilitates adaptive learning experiences calibrated to individual learner profiles and cognitive needs (Ouyang & Jiao, 2021; Chen et al., 2020). While AI's democratization represents a landmark advancement in accessible computational intelligence, it simultaneously unveils complex opportunities and risks within educational settings. By powering systems that rival or exceed human capacities in pattern recognition, information synthesis, predictive modeling, and adaptive reasoning (Chen, Chen, & Lin, 2020), AI introduces profound dualities: it promises unprecedented personalization and efficiency gains, yet risks eroding pedagogical integrity through uncritical adoption, over-reliance, or inappropriate delegation of cognitive responsibilities by both instructors and learners (Chatzipanagiotou, 2025; Tshuma, 2025). Particularly within design education, this tension becomes acute, as AI's analytical strengths must be balanced against the interpretive and creative demands central to the discipline. Recent research confirms that generative tools are most effective when integrated as scaffolds for exploration, synthesis, and reflection, rather than as autonomous decision-making systems. Studies on human-AI collaboration emphasize that students benefit from AI when they are guided to evaluate outputs critically, check sources, and retain responsibility for strategic choices. Within this perspective, AI literacy is increasingly understood as a multidimensional competence that includes technical fluency, critical judgment, and ethical awareness (Schauer, Simbeck & Pinkwart, 2025; Valentine at al., 2026). Yet, despite these emerging insights, empirical evidence remains limited regarding AI's specific impact on design pedagogy, particularly within Strategic Design curricula.

This gap in the understanding of the potential impact of AI on improving or deteriorating the quality of education in the field of design has received insufficient attention from practitioners and educational policymakers. Therefore, the aim of this study is to investigate how AI influences the teaching and learning of Strategic Design within higher education.

2. Methodology

The course provides foundational knowledge, tools, and methodologies in Strategic Design, a discipline that has evolved over the past two decades to address increasing complexity and rapid change in society, markets, and technology. Teaching is grounded in the context of business organizations and integrates theoretical instruction with case studies, practical exercises, and applied design methods. The course aims to develop students' ability to understand and apply the strategic role of design across different organizational models, with a focus on product-service systems and innovation processes. By the end of the course, students are expected to have acquired a basic vocabulary of concepts, tools, and methods specific to these fields, as well as the cognitive flexibility needed to approach and solve systemic design problems. Assessment consists of an oral examination and a coursework assignment that requires students to interpret contemporary social, environmental, or market-related issues and propose strategic design interventions through a tailored proposal.

This study presents an analysis based on questionnaires distributed to students of the course, with the aim of gathering information on the potential use of AI and how it was employed in the development of the assignment's final deliverable. The survey collected 50 responses and employed a mixed-methods structure, combining open-ended questions with Likert scale items. Specifically, the questionnaire was divided into three sections: the first aimed to gather a general understanding of students' use of AI tools in design contexts; the second focused on measuring whether and to what extent they had used AI tools at each stage of the project and whether they had found them useful and/or influential; the third section explored the students' experience of using AI during the project: when it was perceived as useful and when not, its limitations and strengths, and whether they would use it again to carry out the same project from scratch. The responses were compiled into an Excel file and analysed using descriptive statistical methods and visual representations (Hays, 1973). The results were discussed and interpreted by a research group comprising two lecturers and three academic researchers.

3. Results and discussion

A comprehensive survey was administered to former students of the Strategic Design course. The questionnaire combined quantitative and qualitative items and was structured using a 5-point Likert scale, where 1 indicated strong disagreement and 5 strong agreements. In addition, multiple-choice and open-ended questions were included to validate, triangulate, and deepen the interpretation of the Likert-scale responses. The results suggest that AI is already a familiar and relatively consolidated resource in students' design workflows. Respondents reported frequent previous use of AI tools in design-related contexts and generally declared a fair level of confidence in using them. This indicates that AI is not perceived as an entirely external or exceptional technology, but rather as a tool that students have already begun to integrate into their everyday working practices.

A first relevant finding concerns the distribution of AI use across the strategic design process. AI appears to have the greatest impact in the early and analytical phases of the project, especially those involving research, data gathering, synthesis, and comparison. In particular, students associated AI with description of the selected company, product portfolio analysis, SWOT analysis, positioning map relative to competitors, identification of the target audience and analysis of emerging market trends. In these phases, AI was mainly used to accelerate the retrieval and organization of information, to summarize large volumes of material, and to support preliminary sense-making. By contrast, the perceived usefulness of AI decreases in the more interpretative and generative phases of the process, such as the identification of wants and desires, definition of the opportunity, identification of variables and polarities and development of future scenarios. Here, students consistently stressed the importance of human judgment, critical thinking, and contextual interpretation. These phases were perceived as less delegable to AI because they require the ability to make strategic choices, detect nuance, and transform ambiguous inputs into meaningful design directions. In other words, AI helps students read the problem, but humans still seem to be the ones who must frame it strategically. Table 1 shows the mean perceived usefulness of both AI and human contribution across the strategic design phases, with means based on students' responses to 5-point Likert-scale items, with higher scores indicating greater perceived usefulness of AI. While human input is consistently rated as highly necessary and irreplaceable, the use of AI emerges as a valuable support tool whose impact varies by project phase, with generally higher scores during analytical phases and notably lower scores during ideation and generative phases.

Table 1. Mean perceived usefulness of AI and human contribution across strategic design phases.

Strategic design phase	**Mean AI usefulness**	**Mean human usefulness**
Description of the selected company	3.62	4.43
Product portfolio analysis (BCG Matrix)	3.89	4.55
SWOT analysis	3.72	4.34
Positioning map relative to competitors	3.68	4.26
Identification of the target audience	4.34	4.17
Analysis of emerging market trends	2.94	4.83
Identification of wants and desires (WANTS/DW)	2.04	4.77
Definition of the opportunity (HMW)	2.19	4.77
Identification of variables and polarities	2.34	4.72
Development of future scenarios (Scenario Matrix)	1.83	4.53

Another important pattern emerging from the responses is that AI is rarely considered sufficient on its own. Even when its outputs were judged useful, students repeatedly emphasized the need for human intervention to verify, refine, and reinterpret them. This confirms that AI is valued mainly as a support system for cognitive and operational tasks, rather than as an autonomous design agent. Many responses also highlight a recurring issue of reliability, with students noting the need to check sources, correct inaccuracies, and filter generic or overly repetitive suggestions. The open-ended answers in the qualitative sections of the survey answers reinforce this interpretation. Students frequently praised AI for its ability to "speed up research"', "identify connections worth exploring" and "synthesise large volumes of data". Many highlighted its value in expanding initial ideas through "alternative formulations" and "initial insights". However, limitations consistently emerged in stages requiring originality ("AI often produces the same answers, very limiting for creativity") or strategic depth ("Some choices are too important to be delegated

to artificial intelligence"). Numerous respondents emphasised that AI outputs required human review: "AI-generated results only became meaningful after human review" is consistent with comments such as "all tweaked by hand", "source verification" and "critically reworking AI outputs". As one student summarised: "AI provides the raw material; we provide the direction".

Finally, 85% stated that they would reuse AI in similar projects, confirming that its perceived educational value lies in workflow efficiency, whilst preserving the interpretative core for human designers. However, this willingness was accompanied by a clear awareness of its limitations. AI was not imagined as a substitute for Strategic Design, but as a complementary tool that supports research, accelerates repetitive tasks, and offers initial directions to be critically assessed. This is particularly relevant for strategic design education, where students need to learn not only how to use AI, but also when to trust it, when to question it, and when human insight must remain central.

These findings reveal that AI has already achieved significant adoption within student design practices, positioning it as a familiar and actively utilized resource rather than an experimental novelty. Students consistently frame AI as a valuable supporting mechanism, most effective during the initial analytical phases of strategic design where it accelerates information gathering, synthesis, and preliminary pattern recognition. However, its utility diminishes sharply in subsequent interpretive and generative stages, where human judgment, contextual nuance, and strategic synthesis remain irreplaceable. This clear demarcation across process phases underscores a fundamental insight: while AI excels as cognitive infrastructure for structured analytical tasks, it cannot supplant the designerly capacities required for problem framing, opportunity articulation, scenario development, and final strategic adjudication. These findings call for at least a partial rethink of how Strategic Design is taught in the age of AI. As this technology is now an integral part of modern culture and society, rather than discouraging its use in favour of a completely 'human-driven' approach to design, AI should be regarded as a useful tool for boosting productivity and an enabling partner, whose value depends on students' ability to define and critically evaluate outcomes and make informed decisions regarding its use.

The pedagogical implications are multiple. Design educators must develop structured modules that teach prompt generation as a strategic inquiry, transforming random interactions into a rigorous methodological practice. Source verification protocols become essential components of an updated curriculum, teaching students to cross-check AI-generated insights against authoritative materials. Practices of metareflection to document when and why the use of AI proved productive or counterproductive should become standard requirements for assigned tasks, developing students' ability to self-regulate their use of technology within complex workflows. This expanded skills model would not only prepare graduates to use AI tools, but also to integrate them strategically into professional practice. Designers of the future will need to be able to navigate hybrid workflows with ease, harnessing AI's unrivalled analytical speed during the discovery phases whilst retaining interpretative authority during the synthesis and evaluation phases. They must be able to readily recognize the optimal scope of contribution for each: AI for convergent efficiency, humans for divergent creativity and ethical discernment.

4. Conclusions

Ultimately, this study affirms Strategic Design education's enduring mission: cultivating professionals who can navigate irreducible complexity through human-centered foresight. The research reveals three primary insights regarding the integration of AI. First, AI functions effectively as cognitive infrastructure for structured analytical tasks but cannot supplant designerly reasoning required for strategic problem framing. Second, students intuitively recognize AI's zone of optimal contribution, consistently positioning it as a supporting mechanism rather than a Strategic Design substitute. Third, effective human-AI collaboration demands metacognitive calibration, the ability to discern when to engage technology and when to preserve interpretive primacy. AI therefore emerges not as design's replacement but its evolution, expanding analytical capacity while demanding ever-greater interpretive sophistication. The challenge and opportunity lie in educating designers who don't merely tolerate this symbiosis but master it, ensuring human agency remains the strategic intelligence guiding technological amplification toward socially valuable outcomes.

Several research directions merit future exploration. Longitudinal studies could track AI fluency evolution across complete design programs, revealing how critical evaluation skills develop over time. Comparative analyses between design disciplines might illuminate discipline-specific integration patterns and optimal pedagogical approaches. Experimental interventions testing structured AI literacy modules against traditional instruction would provide causal evidence of educational impact. Industry studies examining professional design teams' AI deployment strategies could validate academic approaches against workplace realities.

Strategic Design education must evolve to cultivate designers who master human-AI symbiosis, leveraging technology's analytical power while preserving human interpretive authority. This balanced framework equips design graduates to navigate increasingly complex professional landscapes where technological efficiency must serve human-centered strategic foresight and socially valuable outcomes.

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STRATEGIC MODELS AND HUMAN RESOURCE CHALLENGES IN GLOBAL K–12 AI EDUCATION

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Abstract

AI education has evolved into a global necessity, extending beyond the mere classroom use of AI tools to the integration of AI literacy within K–12 curricula. In this comparative educational policy analysis, we identify four distinct adaptation models currently shaping AI education globally. (1) The Centralized Innovation Model (China) pursues technological leadership and sovereignty. While plans mandate compulsory AI education across all grades by 2025, significant regional disparities in quality persist. (2) The Pragmatic Technocratic Model (e.g., Singapore, South Korea) prioritizes economic efficiency and a "smart society" vision. Here, AI functions as both curricular content and infrastructure (Singapore) or as a dimension of digital literacy (South Korea). (3) The Decentralized Market Model (US, UK) is grounded in institutional autonomy and industry–academia collaboration. Although this facilitates rapid adaptation, the lack of central coordination can exacerbate social inequities in resource-scarce regions. (4) The Humanistic–Civic Model (EU) foregrounds regulation and ethical frameworks, though excessive regulation risks stifling innovation. Across all models, the shortage of appropriately trained teachers constitutes a critical implementation challenge. The uneven distribution of pedagogical support risks creating a new digital divide. While teacher preparedness is a pivotal variable, top-down reforms often provoke resistance, potentially undermining implementation. We conclude that integrating AI into K–12 education is not merely a curricular or technological task, but fundamentally a human resource management challenge.

Keywords: *Artificial Intelligence, elementary secondary education, digital literacy, digital divide, teacher shortage.*

1. Introduction

In the third decade of the 21st century, education systems worldwide are facing an unprecedented challenge: the explosive social diffusion of artificial intelligence (AI), particularly generative artificial intelligence. This process is unprecedented because never before has there been such a rapid, cross-continental, and simultaneous societal demand for education systems to respond to a specific phenomenon (Linderoth et al., 2024). The purpose of this study is to provide a comprehensive overview of the AI integration process in K–12 education through the analysis of international literature and documents issued by various governmental and international organizations. Our analysis proceeds along two main dimensions: we examine various educational policy models related to AI, and we analyze the critical issues of preparing and retaining the teaching workforce from a human resource management perspective.

The success of integrating AI into schools will likely be determined not by technology, but by the human factor. The literature points to a phenomenon termed the "second digital divide." The first such divide stemmed from a lack of access to devices and the internet. In contrast, the second divide manifests in teachers' ICT (and AI) competencies and the quality of pedagogical support (Lin et al., 2023). Students in wealthier, typically urban regions not only have access to AI tools but also have teachers capable of using them creatively to develop higher-order thinking skills. Conversely, in disadvantaged regions, AI is often only mentioned in passing. It might be used as a curiosity without methodological considerations or merely as a drill-and-practice tool. In some cases, due to a lack of teacher competence, it is not utilized at all (Chen et al., 2025). This realization leads to our hypothesis: the most significant bottleneck in K–12 AI education is not the curriculum or access to hardware and software, but rather the adequately prepared teacher.

2. Strategic models in AI education

For AI literacy to be introduced into a national education system, the curricular conditions for AI education must first be established, which requires clear governmental intent. By 2026, the intention to teach AI at the K–12 level had appeared in the official curricula of approximately a dozen countries. However, this has happened to varying degrees and in different formats, ranging from mandatory or elective subjects to pilot programs. In our analysis, we compare four models representing distinct approaches from four major, culturally and geographically distinct regions.

2.1. The centralized innovation model

Among the countries examined, China's strategy is the most ambitious and vertically integrated. The explicit goal of the New Generation Artificial Intelligence Development Plan, issued in 2017, is for the country to become the world's leading AI power by 2030. To achieve this, the Chinese AI education strategy employs a centralized, step-by-step approach focused on building an AI ecosystem. AI education is mandatory for the K–12 age group, and there is strong support in higher education for launching AI-focused programs and integrating AI into other disciplines, such as medicine, engineering, and social sciences (Wu et al., 2020). Educational policy has prioritized the practical development of teachers' AI literacy. This decision followed the realization that teachers' ability to apply AI strongly determines their AI knowledge, as well as their assessment and ethical competencies regarding the technology (Zhao et al., 2022). By the end of 2024, the Chinese government had developed the AI literacy of nearly 3 million teachers through centralized training programs.

The strength of the Chinese centralized innovation model lies in its scalability, scientific foundation, and—aligning with China's social structure—the firm political will behind it, which reliably aids its implementation. However, its main weakness is massive regional inequality. Although the central government attempts to support rural schools with digital platforms and teacher exchange programs, research indicates that the digital divide remains significant, particularly regarding access to quality education (Chen et al., 2025).

2.2. The pragmatic technocratic model

The AI education model of the "East Asian Tigers" is characterized by efficiency, rapid adaptation, and the economic utilization of technology. In Singapore and South Korea, the primary function of education—and AI education within it—is to maintain economic competitiveness.

Singapore's National AI Strategy builds on the principle of human–AI collaboration and development through individual learning paths. Singaporean educational policy treats AI not merely as subject matter to be taught, but as the fundamental infrastructure of the educational ecosystem. In line with this philosophy, their AI education strategy simultaneously aims to develop students' AI literacy within curricular frameworks (Kundu & Bej, 2025) while promoting the use of AI-based tools for personalized and data-supported instruction.

In South Korea, the local national core curriculum was revised in 2022, redefining AI literacy not just as a technical skill, but as a cognitive toolset. Nevertheless, AI literacy is not yet the primary curricular priority; instead, it appears as a dimension of digital media literacy (Choi et al., 2025). A key element of system-level sustainability is ensuring continuous professional development for educators. The government has allocated significant resources for this purpose, setting a goal to retrain tens of thousands of teachers as AI specialists. The South Korean teacher training model is based on the AI-TPACK framework, which combines technological knowledge with subject-specific methodology (Jun et al., 2022). The government's vision is that AI will take over routine tasks of knowledge transfer and assessment, allowing teachers to focus their pedagogical work on mentoring and socio-emotional development.

2.3. The decentralized market model

In the decentralized, market-driven Anglo-American educational systems, central state control is weaker than in the previously discussed countries, while market players, non-profit organizations, and local autonomy play a more dominant role. In the US, there is no unified, mandatory federal AI curriculum. Consequently, regulations implemented by individual states are based on federal guidelines and voluntary national initiatives, which can differ significantly from one another (Joshi, 2025). At the federal level, it is crucial to mention the executive order that marked a political turning point for AI education in the US in 2025 by elevating the issue to the highest level of government. The federal narrative reveals a dual goal: exploring how teaching AI literacy serves labor market preparation (N. Wang & Lester, 2023), while also focusing on student rights, data privacy, and equity (Adams et al., 2023).

The greatest challenge for AI education in the US is the skill level of teachers and the risk of a widening AI divide across different geographic regions and social groups. One consequence of decentralization is that wealthier school districts, often supported by tech companies, can provide excellent AI education, while poorer regions fall behind (Jackson, 2025; Trucano, 2023). Fewer than a third of teachers feel prepared to use AI (Joshi, 2025), and a deepening digital divide is particularly evident in non-white communities (White et al., 2024).

Similarly, the UK lacks a central, comprehensive AI act or an AI curriculum that applies to the entire school system. However, government strategies, guidelines, and manuals do exist, centered around a few core principles. These principles articulate the intention for the UK to be a global leader in AI and data technologies (Gellai, 2023), explicitly viewing the education system as a strategic sector in achieving this goal.

The British approach specifically reinforces the role of the teacher as the primary educator. In this context, AI is treated as a supplementary tool rather than a replacement for teachers (Y. Wang, 2024). The government aims to use AI to reduce teacher workload and increase efficiency and is actively seeking solutions to this end. There is a strong critical discourse regarding the introduction of AI in schools, highlighting the danger that commercial platforms—increasingly acting as knowledge monopolies—are expanding their influence over schools while utilizing student data as a resource (Gray, 2020).

2.4. The humanistic-civic model

The European Union's educational policy regarding AI is characterized by the tension between the pressure of global economic competitiveness and an ethical regulatory framework based on fundamental European values. The EU envisions an AI future where the technology does not replace the educator but rather augments their capabilities and opportunities, all while students become critically AI-literate.

Table 1. Major national AI education strategy models around the world (compiled by the author).

	China (Centralized Innovation)	**Singapore / South Korea (Pragmatic Technocratic)**	**USA, UK (Decentralized Market)**	**European Union (Humanistic-Civic)**
Main Strategic Goal	Global technological dominance, talent development	Economic efficiency, personalization, "Smart Nation"	Serving labor market needs, innovation	Social participation, equity, ethical use
Curricular Model	Multi-level, spiral, mandatory and elective elements	Modular, subject integration	Varies by state, market-driven materials	Transversal competence, project-based integration
Ethical Focus	Security, control, national interest	Responsible use, data protection	Corporate data security, bias, privacy	Human rights, agency, social impact, democracy
Government Control	Strong central control (Top-down)	Strong central control + pragmatic adaptation	Weak central control, strong local/market players	Decentralized, builds on teacher autonomy, varies by member state
Main Challenge	Urban-rural divide, teacher shortage	Social resistance (parents), teacher overload	Unequal access, lack of coordination	Motivating teachers, depth of integration

The EU AI Act (2024), which is binding across the entire European Union, must be integrated into the education systems of individual member states. This legislation uses strict regulations to protect the rights of European citizens—and specifically students—against potential overreach by artificial intelligence and the market or state actors operating it. A prime example is the case of emotion recognition systems. While the regulation does not ban their use, it classifies them as high-risk. Similarly, AI systems used for educational support, such as adaptive learning platforms, have been placed in the high-risk category. In the future, this strict regulation may cause competitive disadvantages for EU citizens and students.

In summary, the speed of legislation and vision-creation in the EU far exceeds the adaptability of schools' infrastructural and human resources. At the same time, the European framework is currently the safest and most transparent AI education system in the world. An additional risk is that over-regulation could slow the entry of innovative EdTech startups into schools, compared to the more flexible models seen in the US or East Asian states.

3. Human resource management in public education in the age of AI

Ultimately, the success or failure of AI-related educational reforms depends on the human factor. The literature unanimously identifies teacher preparedness as the most critical variable (Aravantinos et al., 2026). Education systems must develop complex human resource management strategies covering recruitment, training, retraining, professional development, and retention. A major component of the second digital divide is teachers' lack of AI competence (Rawal, 2024). Teachers frequently perceive the introduction of new technology as a "top-down pressure" that ignores real classroom needs and increases cognitive load (Huang & Yu, 2025). These feelings often lead to resistance and the sabotage of reforms.

The disciplinary approach to teaching AI literacy is not uniform across different education systems. However, the most common solution is to link it to one of the STEM fields, having STEM teachers deliver AI instruction. However, the shortage of STEM teachers is a global problem, and the rapid spread of AI could make it even worse.

3.1. The Problem of AI teacher training

Not every country envisions AI education as a separate subject, but China is pioneering in this area as well. In 2025, Beijing Normal University (BNU) launched the first bachelor's degree program in AI education. Until they can graduate enough qualified AI educators, schools are encouraged to employ industry professionals on a part-time basis. In the US, alternative certification programs allow professionals who hold degrees but lack teaching qualifications to enter the teaching profession through accelerated, practice-oriented pathways. Singapore targets top university students through its Turing AI Scholars Programme, offering attractive scholarships and clear career paths to draw them into AI education and research.

Many countries intend to implement AI professional development systems for in-service teachers. When AI first emerged on a mass scale, many regions launched short, one-off, workshop-style AI training sessions for teachers, often lacking pedagogical context. However, these did not yield the expected success, as fragmented training programs without clear pedagogical objectives have minimal impact. South Korea opted for the "core teachers" model to disseminate AI pedagogical knowledge more broadly. They selected and intensively trained a group of educators to become "AI education core teachers," tasking them with passing on their AI knowledge within their own workplaces and schools. Unfortunately, these teachers often become isolated, overworked, and face resistance from their colleagues. In several other countries, the government provides centralized, institutionalized AI teacher training solutions.

Certain AI teacher training models in Finland and the US are built on the logic of professional learning communities (PLCs). In these communities, educators share their experiences and co-develop teaching materials. This collaborative, mutually supportive learning and working environment increases teachers' commitment to teaching AI while simultaneously reducing their AI-related anxiety (Bautista et al., 2025).

4. Conclusion

The world is not unified when it comes to AI education. The major powers, China and the US, focus on technological innovation and economic dominance. Meanwhile, Europe seeks to protect its own values in this domain as well, prioritizing civic competencies and ethics. Between these two extremes, Singapore and South Korea are attempting to navigate a pragmatic middle path. It is not yet clear which path will lead to definitive success and the full integration of AI into education; investigating this will be the task of future research. However, what is already evident is that the key to successful implementation is proper human resource management. The countries achieving real results are those that handle recruitment and training at a systemic level and can offer clear career paths for those wishing to participate in AI teaching. There is no single, universally applicable solution for AI education.

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INNOVATIVE EXPERIENTIAL EDUCATION: SOCRATIC GAMES FOR ALL

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Abstract

"Socratic Games for All" is an innovative experiential philosophy and artistic education program developed through the Philosophy and Art Laboratory of the National and Kapodistrian University of Athens (NKUA). The program includes two educational models: "Socrates Games" for primary school students and "The Artistic Socrates" for junior high school and high school students. Designed within the framework of doctoral and postdoctoral research under the supervision of university professors, the workshops combine philosophical inquiry, artistic expression, with emphasis on performing arts, and experiential learning to cultivate critical thinking, emotional awareness, democratic dialogue, and social participation.

The pilot experiential workshop "Socratic Games – Artistic Socrates" was implemented by members of the Philosophy and Art Program at NKUA and was based primarily on active student participation as its central pedagogical approach. The workshops aimed to encourage students to think independently, develop argumentative skills, express themselves creatively, and respect different perspectives and experiences. With Socratic dialogue, students explored philosophical concepts such as justice, freedom, friendship, happiness, responsibility, and identity by connecting them to personal experiences and contemporary social issues.

Keywords: *Socrates, experiential education, Socratic dialogue, critical thinking, dramatic skills.*

1. Introduction

Philosophy and theater in combination are best captured in recent performances based on the Platonic text and as an adaptation of different texts referring to the personality of Socrates.

[1]"Socratic Games for all", as an educational innovation program, was inspired by a series of performances under the general title "Socrates on Stage"[2]. The connecting link of all performances is the active participation of the spectators, which functions as a precondition for the success in sharing the theme of the play with a variety of audiences. However, the main goal of these performances is not the theatrical production itself, but the representation that will arouse critical interest and guide the theatrical mediation in search of a timeless truth as a paradigmatic use of philosophical counseling. Contemporary theatrical representations of Socrates transform Platonic philosophy into an experiential educational practice that combines artistic performance with active philosophical inquiry. Through dialogue, participation, and reflection, audiences engage critically with ethical and social questions both inside and outside the classroom. These performances highlight the continuing global relevance of Socratic thought as a dynamic tool for education, culture, and democratic dialogue. Other significant moments of previous research have been:

- *The dramatic persona of Socrates between philosophy and drama during the 20th and 21st centuries* (PhD thesis 2022 by I. Spyridis), (Spyridis, 2022),
- a series of articles published in English and Greek by Anna Lazou and Giannis Spyridis (Lazou & Spyridis, 2023; Lazou, 2020; Lazou & Spyridis, 2019),

[1] *Apology of Socrates* (Yiannis Simonidis), *Socrates on Trial* (Andrew Irvine - Anna Lazou), and *Socrates Now* (Dimos Abdeliodis). These productions have recently been presented before the public of *diaspora* Hellenism with encouraging results.

[2] The project *Socrates on stage* started in 2015, performing Andrew Irvine's play *Socrates on Trial* (premiere in Athens, October 2015- in the theatre *Alcmene*). Ever since, there have been several repetitions of the performance based on Giannis Spyridis' translation and Anna Lazou's direction, with the participation of amateur and professional actors and students of philosophy.

- experiential educational programs for young and adult people and teams,[3]
- *staging* philosophical texts in the context of the newly established laboratory of Philosophy & Art of Athens University (*Phil.Art.Lab*.).
- In 2023, members of the Laboratory's research team (Dr Yorghos Voutos, Dr Giannis Spyridis, and Dr Anna Lazou) presented a critical survey of the 'Socrates on Stage' project at the 1st International Conference for the theatre of the Hellenic Diaspora Campus Solbosch, Université Libre de Bruxelles.[4]
- The school project "Philosophizing…. a tour through moral values" since 2020, involving students 12 to 15 years old, at the 8th Junior High school of Chalandri, Athens (coordinated by Nektaria Skouteli, MA)

Our research proposes that Plato reinforces a radical change in the Athenian theatrical reality, at a distance from the old ways of creating and conveying drama and by applying new methods such as: reading texts by a performer to small audiences, provoking philosophical questioning and finally, avoiding spectacular movements or dance – chorus – acts (Puchner, 2010).

2. Design

The experiential workshops were designed as two-hour sessions or as two consecutive sessions of 45 minutes, to be implemented both within the school environment and in alternative educational and cultural settings outside the classroom. In addition, the program included the possibility of a two-day educational and cultural visit to Ancient Epidaurus, where students, parents, and teachers could participate in workshops functioning as a summer school centered on theatrical adaptations of Platonic dialogues and Aristophanes' comedy related to the figure of Socrates.

2.1. Philosophy in action: A Socratic journey through dialogue, drama and dance

The work team, consisting of members of the Philosophy and Art program at NKUA (National and Kapodistrian University of Athens), coordinated by Dr. Anna Lazou, associate professor of Aesthetics of performing arts, visited the 8th Junior High School of Chalandri, Athens, Attica, in the context of presenting the pilot program on 17 March 2026 (Figure 1).

Initially, the school's Philosophy Group, consisting of thirty students from all three grades of junior high school, was divided by the program facilitators into two groups of fifteen participants. The facilitators began with ice-breaking and relaxation games through experiential activities that encouraged the students to express themselves creatively and spontaneously. Among the activities was the depiction of their emotions on A4 paper through drawing, which contributed to the creation of a warm and familiar atmosphere that fostered cooperation. Subsequently, Anna Lazou, setting the rhythm with the accompaniment of a drum, introduced the students to the 9/8 meter, bringing them closer to the rhythm and aesthetics of ancient Greek dance. The students participated with remarkable enthusiasm and vivid interest.

Afterwards, photocopies of Aristophanes' comedy *Clouds,* adapted by Andrew Irvine, Professor of Philosophy of Columbia University and author of the play *Socrates on Trial* (translation in the Greek language by Dr Giannis Spyridis), were distributed to all groups of students. Each group read the text and assigned roles among its members. The theatrical presentation of the dialogues created amusement and excitement among the students, while also inspiring a friendly sense of competition regarding which group would deliver the best performance.

[3] For reasons of historical documentation of our contribution to the *1st International Conference for the Theatre of the Hellenic Diaspora*, it is worthwhile to mention that the Research and Artistic group of Athens University *dryos topoi* has participated several times to international University theatre events in Europe and other continents (Belgium, Italy, Germany, Poland, Belarus, Mexico, Tunisia, Canada) with various plays and performances of ancient and modern drama and dance theatre. In February 2005, *Dryos Topoi* presented *Nekyia; the Archetypal Journey* (after Homer) at the University Theatre Festival of Liege *RITU* (pres. Robert Germay), and at the same period, in Brussels' theatre *Scarabaeus* (dir. Irene Chalkia). https://www.greece-athens.com/article.php?article_id=29; http://dryostopoi.phil.uoa.gr/index.html

[4] https://www.hellenicbridge.org/news/theatre-hellenic-diaspora/

In Andrew Irvine's *Socrates on Trial*,[5] the first act refers to the *Clouds* and the second to *Apology*. Initially, the comic atmosphere created by Aristophanes' mocking of the Sophists for their paid teachings and, on the other hand, the corruption that Socrates induces in young people, shapes the theme of the play, where the dominating moral question is about what is and what is not right. The meeting culminated in thoughtful reflection and questions from the students about issues inspired by Aristophanes' text, which the coordinators handled with skill and pedagogical sensitivity. The event concluded joyfully with traditional Greek dances that matched the comedy's joyful atmosphere.

3. Objectives

We argue in favor of a validly applied interrelation between philosophy and theatre today, in which the Platonic drama proves to be of great value as a literature genre that stands among them. Therefore, we support that in Andrew Irvine's play and the experience of staging *Socrates on Trial* in its Greek version, we have a genuine example of an educational and therapeutic application of philosophy through art. Our aim, among others, had been to support the idea that this goal of a theatrical project like the one we experienced with Andrew Irvine's *Socrates on Trial*, could enrich philosophical didactics within the University by adding an innovative and wider, as well as socio-political perspective, outside the typical classroom and different than the established academic learning processes. Applied to the school environment, our objectives allow students to engage intellectually, emotionally, and socially with philosophical themes while linking abstract concepts to everyday adolescent concerns.

Outside the classroom during a summer school to be realized in June and October 2026, in the monumental surroundings of Ancient Epidaurus, where theatre, history and culture unite, assuming that Socratic philosophy is a starting point for an alternative method of philosophical education, the Platonic allegories can be used by employing specific dramatic techniques as teaching tools addressing most of the problems concerning human life, culture, and critical moral issues in open audiences e.g. students and their parents (Lazou & Spyridis, 2023).

4. Methods

A central methodological component of the program was the Socratic method, in which facilitators guided students through questions rather than direct instruction. Educators acted as facilitators and co-participants in dialogue, encouraging reflection, inquiry, and collaborative learning. Knowledge emerged through observation, discussion, interpretation, and self-expression rather than through traditional teacher-centered teaching practices. The workshops incorporated a wide range of experiential and artistic methods, including role-playing, theatrical improvisation, creative writing, visual and performing arts activities – including dance & music -, sharing views on philosophical dilemmas, and group dialogue. Topics explored included peer relationships, bullying, social media, human rights, ethical dilemmas surrounding artificial intelligence and technology, and questions of personal and collective responsibility.

5. Discussion / Conclusions

The evaluation of the pilot workshops demonstrated significant educational and social benefits. Students participated actively and freely in a safe and inclusive environment without fear of evaluation or criticism. Increased engagement was observed even among students who are usually reluctant to speak in traditional classroom settings. Participants strengthened skills related to critical thinking, argumentation, active listening, empathy, collaboration, and creative expression. They also demonstrated an increased ability to connect philosophical reflection with real-life experiences and contemporary ethical issues.

Overall, the program contributed not only to students' cognitive development but also to their emotional and social growth. By transforming philosophy into an experiential and participatory process both inside and outside the classroom, "Socratic Games for All" demonstrated how philosophical education can function as a powerful tool for democratic participation, personal development, and creative coexistence within a genuine community of dialogue.

Conclusively, the Platonic drama is of great value today as it has the potential to offer self-evaluation and personal development through philosophical thinking. Art and drama unfold the human soul and strengthen it through physical action, emotional expression, and social exploration.

[5] Andrew David Irvine teaches philosophy at the University of British Columbia's Okanagan campus. He is the author of the internationally acclaimed *Socrates on Trial* (Irvine, 2008), a stage play based on Aristophanes' *Clouds* and Plato's *Apology, Crito,* and *Phaedo*. Author of *Lysistrata- An Adaptation* https://www.youtube.com/watch?v=-yn1xSa7z00, https://www.youtube.com/watch?v=uNKkd4xMyW8

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The next phases of the project include the repetition of the workshops outside the classroom and in the monumental surroundings of Ancient Epidaurus, encouraging the young participants with their parents to philosophize in the historically significant countryside as part of their educational experience.

Figure 1. Photographic instance of the pilot workshop at the 8th Junior High School of Chalandri, Athens, Greece, 17 March 2026; featuring Dr Anna Lazou, Mrs Nektaria Skouteli, the team of coordinators, and the students.

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THE ROLE OF GENERATIVE AI IN LOW-CODE ROBOTICS IN STEM EDUCATION

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Abstract

The integration of generative artificial intelligence (GenAI) tools into low-code robotics platforms is sharply changing how educational robotics is integrated in science, technology, engineering, and mathematics (STEM) education. This paper presents a combination of an empirical study and a theoretical positioning to examine the integration of GenAI into low-code robotics within STEM education. The main aim of the study is to examine how GenAI facilitates progress in learn-to-code from basic syntax mastery, such as block-based programming, to advanced system architecture design that integrates multi-agent coordination, sensor fusion, and the ethical deployment of robots in STEM disciplines. Following PRISMA 2020 guidelines, 42 studies conducted between 2022 and 2026 were reviewed from databases including Scopus, Web of Science, IEEE Xplore, and ACM Digital to establish the theoretical positioning. In the empirical study, three low-code-generated STEM robot designs and workflows were analysed deductively to provide a thick description of what is feasible. Findings from both the empirical study and the review suggest that GenAI tools can make programming more approachable for beginners by helping them get started with simple code, providing debugging support, and offering Personalised scaffolding. At the same time, these tools can help learners gradually build the confidence and skills needed to take on more complex tasks, like designing modular systems and improving their work through ongoing refinement. From the analysis of developed robots, although generative AI offers many benefits, several challenges remain when Gen AI tools are used for programming. These challenges include learners still over-relying on AI-generated responses; equity issues related to language and cultural biases that continue to surface in Gen AI responses. This gap clearly shows a need for a well-structured teaching framework that thoughtfully blends human input with Gen AI collaboration. The Implications of this review suggest the need for a conceptual pathway for GenAI-augmented low-code robotics curricula and identify directions for educators and researchers to implement and validate the proposed framework.

Keywords: *Generative AI, low-code robotics, prompt engineering, STEM education, system architecture, syntax mastery.*

1. Introduction

The digital divide in STEM education has historically been defined by the "syntax barrier". The Syntax barrier refers to the initial steep learning curves that beginners face due to their lack of familiarity with coding rules (Syntax) and which prevents the execution of a computer program (Sarkar & Drosos, 2025). In the aspect of coding, the high cognitive load required to master programming languages before a student can engage with robotics hardware also creates a barrier to the actualisation of any product. So, looking at this objectively, the syntax barrier has discouraged students from pursuing robotics because mastering complex code is frustrating. The emergence of low-code platforms sought to lower this barrier, yet the transition from simple block-based logic to complex, real-world robotic applications remains a significant pedagogical hurdle when teaching young minds how to code for artefact generation. This study examines theoretical drivers and three cases of 11th graders versed in using the Arduino coding cloud to generate STEM robots.

The advent of Generative AI (GenAI) has introduced a transformative layer to this ecosystem. By allowing students to describe robotic functions in natural language, GenAI tools facilitate a smoother transition through the coding hierarchy (Creely, 2026). However, the mere presence of these tools does not guarantee the educational quality of the Robots developed; there is a pressing need for a structured framework or pathway that ensures GenAI remains a scaffold rather than a crutch. This paper addresses this gap by proposing a structure which will eventually lead to the generation of a model that integrates human agency with AI efficiency.

2. Theoretically speaking

Integrating GenAI into educational robotics, particularly with hardware architectures such as Arduino or ESP32 microcontrollers, requires a strong theoretical foundation that combines cognitive scaffolding with computational pedagogy. This study is underpinned by the Cognitive Load Theory (CLT) and the emerging GenAI-Enabled Computational Thinking (Creely, 2026; Ouaazki et al., 2026). The problem that drives this study is situated in a phenomenon called syntax overload, which is an extraneous cognitive load caused by bracket placements, semicolons, and low-level C++ pin configurations, when beginners start to learn to code. Syntax overload usually diverts working memory from focus and commitment when developing artefacts, especially targeted for STEM. The research question that arises from this challenge is: How can GenAI be used to effectively, in combination with human agency, to support robot generation in STEM education?

Introducing GenAI as an epistemic partner via conversational "vibe coding" (Sarkar & Drosos, 2025) automates lower-level syntax tasks, enabling students to focus on higher-level problem-solving, systemic abstraction, and algorithmic design. This human-AI co-creation changes the learning cycle, shifting the primary task from deterministic code writing to an iterative, meta-cognitive exercise in prompting, executing, and evaluating AI output against a robot's physical actions (Creely, 2026). Consequently, GenAI integration offers a personalised cognitive scaffold that connects abstract mathematical and biological logic with tangible hardware engineering, reducing barriers to digital physical innovation while enhancing domain-specific STEM mastery and problem solving (Hsu et al., 2022).

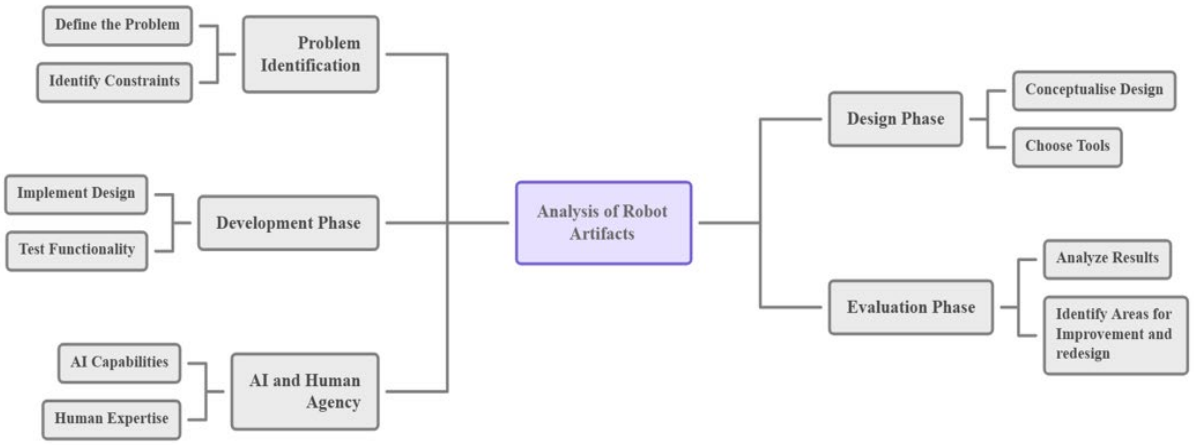
3. Methods and design

Two approaches were adopted for this study. First, a systematic review to understand the theoretical perspectives of low-code robotics, and second, a qualitative artefact analysis of the workflow and design of three students' robot creations.

For the theoretical perspective, the PRISMA 2020 guidelines were followed to select recent work from 2022 to 2026 to ensure a rigorous and transparent synthesis of current research. Databases interrogated during the search include Scopus, Web of Science, IEEE Xplore, and the ACM Digital Library. The inclusion criteria included articles and conference papers published between 2022 and 2026 that focused on GenAI in the context of robotics and STEM pedagogy. Book chapters and periodicals were excluded, as were web blogs. All due processes were followed to read and analyse these excerpts from all selected sources.

In the thematic analysis of the literature, 42 key studies were interrogated, and the findings were synthesised into three primary dimensions: learner scaffolding, system architecture design, and the ethical deployment of robots. For artefact analysis, all dimensions of the project planning and phases were analysed. Figure 1 below shows the dimensions that were considered from the design through to the analysis of artefacts.

Figure 1. Pathway from design to artefact analysis.



3.1. Phase I: Problem identification and ideational prompting

In this initial stage, the students' roles were shifted from passive recipients of tasks to "Prompt Engineers" of solutions. Students began by identifying a specific challenge within their community and the broader STEM field that could be addressed using crafted robots. After identification, students used GenAI to conduct preliminary research and feasibility studies to develop their proposed robot solution. Instead of a simple search, they engage in iterative chain-of-thought prompting to break a large problem into smaller robotic sub-systems. The analysis of student chats in this phase showed that GenAI acted as a brainstorming assistant, helping students refine their project's scope and identify necessary robotic components.

3.2. Phase II: Scaffolding the learn-to-code progression

This phase addresses the "syntax mastery" by using GenAI as a dynamic tutor. For two of the three students who did not have good Arduino coding knowledge, GenAI translated high-level logic into block-based structures that they could easily follow. While some students already knew quite well how to code with Arduino. As the beginner students progressed, the AI provided the corresponding text-based code, explaining the syntax line by line. All of this was accomplished using the Arduino AI Assistant within Arduino Cloud and occasionally ChatGPT and Claude via a split-screen browser window.

Analysing the prompt history and troubleshooting logs also showed that debugging loops offered students valuable learning opportunities. GenAI provided real-time, personalised scaffolding, helping students identify logic errors without the "blank page" anxiety that goes on when students are on their own.

3.3. Phase III: Advanced system architecture

The final phase of analysing the artefact moved beyond simple motor control to complex system design. Looking at how the participants integrated sensors in their robots and how they managed multi-agent coordination in their product. GenAI assists in writing complex filtering algorithms that enable multiple sensors to interact and also helps debug errors. Finally, students reported on how they used GenAI to simulate ethical dilemmas or environmental impacts of their robotic designs.

4. Results and discussions

The synthesis of studies and analysis of the actual artefact designs revealed that GenAI significantly boosts learner confidence by allowing them to take on more complex tasks through ongoing brainstorming and refinement loops with different GenAI tools. Table 1 below summarises some of the insights from the analysis.

Table 1. Core themes generated both from theory and cases.

Your Potential Finding	Core Theme	Supporting Academic Literature
Students who prompt iteratively for debugging show deeper mastery than those who ask for full code blocks.	**Student Agency & Help-Seeking**	(Creely 2026) highlights the risk of executive delegation vs. the benefits of instrumental exploration by students
Lowering the technical coding barrier allows students to focus on complex physics/biology logic.	**Higher-Order Thinking (HOT)**	Meta-analyses show Gen AI exerts a strong positive effect on problem-solving and critical thinking by acting as personalised scaffolding (Zhao et al., 2025).
Students develop robust prompt patterns (e.g., assigning the AI a "Persona") to produce better sensor calibration code.	**Prompt Engineering Literacy**	Mzwri & Turcsányi-Szabo (2025) note that explicit or experiential mastery of prompt patterns enhances autonomous learning and self-regulation.

From Table 1, the findings reveal the following themes as discussed below.

4.1. GenAI tools as a help-seeking tool

Findings reveal that higher-performing students typically engage in instrumental help-seeking. They use natural language to prompt the GenAI tool for conceptual guidance, error debugging, or modular code blocks, treating the AI as an adaptive tutor. Conversely, lower-performing or less confident students tend to seek executive help, delegating entire tasks to GenAI tools. For example, one of the logs from participants asked the Arduino assistant for "complete code for a titration robot" and passively copied and pasted the output without parsing its logic.

This finding aligns with Creely (2026), who found that, in an undergraduate setting, GenAI currently "mirrors student intent" rather than automatically optimising for learning. This means if a student approaches the AI passively, the tool complies passively, which can lead to accepting the first functional script without critical iteration or alternative exploration (Creely, 2026).

4.2. Cognitive scaffolding and the reduction of syntax overload

Building physical robots usually presents a steep learning curve because students must master hardware wiring and syntax-heavy coding (like C++ for Arduino) simultaneously for a viable product to be generated.

However, it was clear that a low-code AI assistant can act as a powerful cognitive bridge to help students achieve their development goals. Automating the syntax generation significantly reduced students' cognitive load. This allows 11th graders to focus their intellectual energy on the high-level logic of the robot (e.g., *How do we translate a change in light intensity into motor steps to track phototropism?*). This finding concurs with the literature on high school students' computational thinking, particularly in the dimensions of abstraction and algorithmic thinking when GenAI is integrated for assistance. Gen AI is able to eliminate initial syntax-related frustrations, which historically discourage novice learners, and maintains high learning enthusiasm, which supports exploration in a risk-tolerant environment (Hsu et al., 2022; Ouaazki et al., 2026).

4.3. The epistemological shift: From "doing code" to "evaluating output"

In traditional robotics tasks, success is measured by procedural correctness related to code compilation. However, the findings from this study reveal that an AI-mediated environment shifts toward meta-cognitive regulation and critical evaluation. Because the AI can generate code instantly, the students' primary challenge shifts from writing code to testing, validating, and debugging the code against physical reality. For example, if the GenAI generates code for the Snell's Law optics robot, the students must critically evaluate why the physical laser arm is overshooting its target and refine their prompts accordingly. These findings reflect what educational researchers describe as an epistemological shift in STEM education: transitioning from traditional knowledge transmission to knowledge co-construction mediated by intelligent systems (Pacheco-Olea & Villacís-Macías, 2026). The literature notes that AI shifts the focus away from purely deterministic problem-solving toward interpretability, validation, and the management of human-AI collaboration.

4.4. The challenges associated with GenAI integration remain

Several challenges, including the over-reliance trap, in which students may become overly dependent on AI-generated code without understanding its underlying logic, often arise during the process. In addition, equity and cultural biases inherent in GenAI training data continue to surface, potentially disadvantaging students from non-dominant cultural or linguistic backgrounds. The "Black Box" risk, in which successful implementation requires students to manually "annotate" AI-generated code to prove comprehension and ensure a "human-in-the-loop" approach, revealed gaps in some cases.

5. Conclusion and implications

Holistically, this study advocates that it is important to provide a roadmap for students to integrate GenAI when coding to create robots for STEM disciplines without sacrificing the requisite pedagogical integrity and the learning of core syntax through the learn-to-code progression. From all that was experienced and analysed, GenAI can become a powerful scaffold for robotics learning and not a replacement for the thinking process that must be applied in creation. Integrating GenAI into low-code environments also supports inquiry-based and project-based learning. In addition, GenAI was found to be useful in schools with limited specialist coding expertise, facilitating progression from block-based to text-based programming with adequate teacher guidance and a ‘human-in-the-loop’ pedagogical approach.

The best impact of low-code GenAI environments occurs when paired with learner agency, reflection, and contextual problem-solving. Future research should focus on developing frameworks that span diverse cultural contexts. For robotics educators, there must be an intentional shift from evaluating only code correctness to focusing more on students' ability to explain the thinking and logic behind their syntax, as well as their ethical use of GenAI to arrive at the end product.

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TRANSFORMATIVE LEARNING FOR SUSTAINABILITY: A SYNTHESIS OF LEARNING OUTCOMES

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Abstract

Although the transformative learning outcomes have been examined in the literature, there is limited discussion of whether these outcomes differ in a sustainability context, or of the additional dimensions that sustainability learning may introduce. This paper addresses the research question of what the learning outcomes in transformative learning for sustainability are and how they can be evaluated. The analysis is based on an integrative literature review (n=14). The study presents a synthesis of transformative learning outcomes for sustainability comprising an ecologically grounded and systemic worldview, critical sustainability awareness, respect and care for others and the non-human world, motivation for sustainability action, collaborative capacity, and sustainability agency. The evaluation of these learning outcomes warrants further research.

Keywords: *Transformative learning, education for sustainable development, learning outcome, higher education, integrative review.*

1. Introduction

The persistent problem of unsustainability and the transgression of planetary boundaries highlight the urgent need to transform prevailing frames of reference and to foster more sustainable mindsets, social practices, and institutions (Boström et al., 2018). The significant potential of transformative learning theory (Mezirow, 1997; Kitchenham, 2008) to advance sustainability education has been widely recognised (Sipos et al., 2008; Boström et al., 2018). The central idea of the transformative learning theory is the transformation of frames of reference, which occurs through critical reflection on underlying assumptions and engagement in dialogue through which new meanings are constructed (Mezirow, 1997). Learning outcomes, i.e. the final results of the learning process, have the potential to act as drivers of sustainability transformation.

Separate fields of study discuss transformative learning outcomes (Stuckey et al., 2013; Hoggan, 2016), and sustainability competencies (Redman & Wiek, 2021; Brundiers et al., 2021). However, there is not much literature available that has brought together these perspectives and examined what the transformative learning outcomes in the context of sustainability are. There is limited discussion of whether transformative learning outcomes differ in a sustainability context, or of the additional dimensions that sustainability learning may introduce. Furthermore, many studies in sustainability education focus on transformative pedagogy and learning activities and only briefly mention intended learning outcomes. This paper addresses the research question of *what the learning outcomes in transformative learning for sustainability are and how they can be evaluated*.

2. Transformative learning outcomes

Previous literature has conceptualised transformative learning outcomes (see Table 1). Transformative change – as opposed to minor or incremental change – entails "an existential change that is more global in nature, a change in worldview and lifestyle rather than a change in a specific belief of behavior" (Stuckey et al., 2022, p. 1460). Hoggan (2016a, p. 71) understands transformative learning outcomes as "significant and irreversible changes in the way a person experiences, conceptualises and interacts with the world", metaphorically representing heart, head, and hands. Transformative learning is therefore both comprehensive and profound. Hoggan (2016b) further emphasises that, in transformation, the learner changes in a fundamental way, requiring impact that is deep (depth), spans multiple life contexts (breadth), and is not temporary (relative stability).

Table 1. Transformative learning outcomes by Stuckey et al. (2013; 2022), Hoggan (2016a; 2016b) and Cox (2021) and their suggested matching.

	Stuckey et al. (2013; 2022)	Hoggan (2016a; 2016b)	Cox (2021)
Hands	***Acting differently***: Changes in behavior that are remarkedly different from previous behaviors	***Behaviour***: Actions consistent with new perspective, Social action, Professional practices, Skills	I made major changes in my life This program changed my life
Head	***Worldview Shift***: Shift in paradigm that radically alters a perspective and replaces a prior thought process or way of being	***Worldview***: Assumptions, beliefs, values, expectations, Ways of interpreting experience, More comprehensive or complex worldview, New awareness/new understandings	My view of the world changed My deeply held beliefs changed
	Open Perspective: Receptivity to new ideas and experiences, often involving curiosity and seeking to understand others' point of view	***Epistemology***: More discriminating, Utilising extrarational ways of knowing, More open, Shifts in thoughts and ways of thinking, More autonomous thinking, More complex thinking	
		Capacity: Cognitive development, Consciousness, Spirituality	
Heart	***Self-Awareness***: Conscious reflection and knowledge of one's own character, values, feelings, motivation, and impact on others	***Self***: Self-in-relation to others/world, Empowerment/Responsibility, Identity/View of self, Self-knowledge, Personal narrative, Meaning/purpose of persons life, Personality	My view of myself changed I developed a greater sense of responsibility toward others
		Ontology: Affective experience of life, Ways of being, Attributes	I changed my goals for the future

3. Method

This study adopts an integrative literature review approach, which "reviews, critiques, and synthesizes representative literature on a topic in an integrated way such that new frameworks and perspectives on the topic are generated" (Torraco, 2005, p. 356). A systematic search was conducted in Scopus and Web of Science by using the following search query: (TITLE (transformative OR transformational) AND TITLE (sustainability OR "sustainable development") AND TITLE-ABS-KEY (learning OR education) AND TITLE-ABS-KEY (outcome* OR competenc*)). A web-based systematic review management tool, Covidence, was used to organise the review process. After the removal of duplicates, the search yielded 70 articles. Only peer-reviewed journal articles and review papers published in English were included, and no time restrictions were applied. Following title and abstract screening, 29 irrelevant sources were excluded. Subsequently, full-text screening led to the exclusion of a further 27 studies. Studies were excluded if they did not address learning outcomes, were not focused on transformative learning, or did not concern sustainability education. Consequently, a total of 14 articles were included in the review for in-depth analysis. Integrative literature reviews require conceptual structuring to clarify how the main concepts of the topic come together as a unified idea (Torraco, 2005). This review is structured around the three learning domains: cognitive, affective (or social-emotional), and psychomotor (or behavioural) (Hoque, 2016; UNESCO, 2019). This tripartite division of learning, metaphorically represented as head, heart, and hands (Sipos et al., 2008; Hoggan, 2016a), has its roots in established learning theories and is also widely applied within education for sustainable development.

4. Results

4.1. Overview of learning outcomes in transformative learning for sustainability

The reviewed articles (n=14) were published between 2017 and 2026, with the majority appearing within the last three years, indicating that academic engagement with the topic is relatively recent. The literature examines transformative sustainability learning outcomes across a range of disciplines, including agriculture (Probst et al., 2019), hospitality (Wang & Teng, 2019), leadership (Bryant et al., 2023; Brooks & Brooks, 2024), innovation and business (Macagno et al., 2024; Viera Trevisan et al., 2024; Xiao et al., 2025), architecture and construct management (Bales et al., 2025; Siva & Ershadi, 2025), language education (Hämäläinen 2025) and planning (Ziafati Bafarasat et al., 2025), as well as more generally through reviews (Rodríguez Aboytes & Barth, 2020), conceptual development (Ziafati Bafarasat et al., 2025) and interdisciplinary workshops (Fagerholm et al., 2026).

Most of the articles (Probst et al., 2019; Rodríguez Aboytes & Barth, 2020; Bryant et al., 2023; Brooks & Brooks, 2024; Macagno et al., 2024; Bales et al., 2025; Siva & Ershadi, 2025; Ziafati Bafarasat et al., 2025; Fagerholm et al., 2026) conceptualise the learning outcomes of transformative learning for sustainability as multidimensional, encompassing cognitive (head), psychomotor (hands), and affective (heart) aspects. Many studies rely on their conceptualisations on previous frameworks: Bryant et al. (2023) and Brooks & Brooks (2024) propose that transformative learning for sustainability can be captured by Hoggan's (2016a; 2016b) typology of transformative learning outcomes. In addition, Brooks & Brooks (2024) refer to Inner Development Goals (n.d.). Probst et al. (2019) rely on Stuckey's et al. (2013) categorisation of transformative learning outcomes. Xiao et al. (2025) conceptualise outcomes based on

sustainability competencies by Redman & Wiek (2021) and Brundiers et al. (2021). Fagerholm et al. (2026) uses the five clusters of inner-outer transformation by Wamsler et al. (2021). The conceptualisations share many common elements; however, it is evident that there is no established or standardised approach to conceptualise learning outcomes in transformative learning for sustainability.

This lack of consensus is even more pronounced with regard to the evaluation and assessment of learning outcomes. Only Probst et al. (2019) address the assessment or evaluation of transformative learning outcomes in their study by developing a theory-led instrument to assess sustainability learning outcomes. In other studies, learning outcomes are identified either through the analysis of data collected from participants in transformative learning courses or programmes, or through systematic reviews of the existing literature. Consequently, the majority of the articles do not provide specific measures for assessing learning outcomes; instead, they rely on qualitative and quantitative analyses of students' reflections, concept maps, interviews, or survey data. Based on existing studies, the evaluation of transformative learning outcomes for sustainability appears to be a relatively under-discussed topic in the literature. However, the associated challenges are acknowledged. Xiao et al. (2025) note that an emphasis on immediate learning experiences does not capture whether these translate into long-term behavioural changes towards sustainability beyond the classroom. Similarly, Fagerholm et al. (2026) call for further development in assessment and evaluation approaches, recognising that traditional assessment methods may not be suitable for capturing the qualities and capacities of inner-outer transformation for sustainability.

4.2. Learning outcomes of 'Head'

Although some articles identify sustainability-related knowledge as a learning outcome (Rodríguez Aboytes & Barth, 2020, Macagno et al., 2024; Viera Trevisan et al., 2024; Siva & Ershadi, 2025; Ziafati Bafarasaet et al., 2025), many place greater emphasis on more profound cognitive change. This is variously described as a change or shift in worldview (Bryant et al., 2023; Brooks & Brooks, 2024), the development of systems thinking or a holistic approach (Rodríguez Aboytes & Barth, 2020; Macagno et al., 2024; Hämäläinen, 2025; Xiao et al., 2025), a transformation of mindset (Macagno et al., 2024), or the emergence of new insight (Fagerholm et al., 2026). Across these perspectives, a systemic and relational orientation is emphasised, in which the worldview becomes broader and more complex, enabling recognition of the interconnectedness of sustainability problems. Fagerholm et al. (2026) define based on Wamsler et al. (2021) insight as "the ability to think from a relational, equitable, and systems perspective that recognises complexity and interconnectedness". Harmin et al. (2017) refer to a reconceptualisation of relationships, whereby relations with the more-than-human become less anthropocentric, positioning humans and the more-than-human as relational equals within ecological systems. Similarly, Brooks and Brooks (2024) describe a worldview change in which a new understanding of the self as part of nature is formed. Many studies also identify forms of critical thinking and awareness as key learning outcomes. These are described variously as an increased awareness of structures that perpetuate unsustainability (Bryant et al., 2023), the deconstruction of power relations and epistemic hegemony (Harmin et al., 2017), and critical thinking that acknowledges the influence of power structures (Rodríguez Aboytes & Barth, 2020). Fagerholm (2026) conceptualises awareness as the capacity to be present, open, self-reflexive, and attentive.

4.3. Learning outcomes of 'Hands'

Many of the reviewed articles place strong emphasis on behavioural learning outcomes. These are described as behavioural intentions (Viera Trevisan et al., 2024), a sense of agency and empowerment (Rodríguez Aboytes & Barth, 2020), as well as actual behavioural change (Siva & Ershadi, 2025) and sustainability-focused behaviour (Bryant et al., 2024). Accordingly, authors differ in whether they seek to capture observable behavioural change or the potential and capacity for sustainability-related agency. Such outcomes are regarded as particularly important in the context of sustainability education, where the focus is not only on learning about sustainability but also on developing the capacity to advance societal change and transformation. Macagno et al. (2024) argue that mindsets and creative confidence, comprising creative agency and creative self-efficacy, are equally important to solving sustainability problems as sustainability literacy. Similarly, Bales et al. (2025) argue that declarative, disciplinary knowledge may be counterproductive for transformation if students' personal bodies of sustainability-related knowledge and motivation are replaced by more academic and less personal framings. In such cases, students may experience a loss of autonomy, agency and empowerment, thereby undermining transformative learning. Furthermore, collaborative capacity is highlighted in some studies (Macagno et al., 2024; Siva & Ershadi, 2025; Xiao et al., 2025; Fagerholm et al., 2026). The ability to foster collaboration among diverse stakeholders is considered crucial for addressing interdisciplinary sustainability challenges (Siva & Ershadi, 2025).

4.4. Learning outcomes of 'Heart'

Affective learning outcomes relate to relational values (Rodríguez Aboytes & Barth, 2020; Fagerholm et al., 2026), environmental attitudes (Probst et al., 2019) and motivation for sustainability (Wang & Teng, 2019; Bales et al., 2025). Fagerholm et al. (2026) argue that the root of the sustainability crisis lies in an inability to relate to ourselves, others, and the environment in compassionate and caring ways, and that a transformation of these relationships is therefore required. They emphasise connection and compassion towards other people and living things as key learning outcomes. Similarly, Bryant et al. (2023) describe ontological change as a shift from self-interest towards more collective concerns, highlighting the relational nature of the self and a sense of interconnectedness with others and the world. Rodríguez Aboytes and Barth (2020) refer to the reconstruction of values, whereby learners become more empathetic and oriented towards collective concerns. Furthermore, motivation and passion to engage with sustainable practices and to respond to environmental and social impacts are seen as the basis for motivated action (Wang & Teng, 2019; Bales et al., 2025).

5. Discussion and conclusions

Most of the reviewed studies conceptualise transformative learning outcomes as final and measurable sustainability-related results. An exception is Probst et al. (2019), who examined the transformative learning experience itself and subsequently analysed whether it predicted sustainability-related attitudes, skills, and agency. Rodríguez Aboytes and Barth (2020) similarly acknowledge that it is not always clear whether transformative learning should be understood as a learning outcome in its own right or a means of achieving other outcomes. This ambiguity might stem from the separate development of measures for sustainability competencies and transformative learning experiences. Figure 1 presents a synthesis of transformative learning outcomes for sustainability derived from the reviewed literature, integrating transformative learning experience into sustainability education outcomes.

Figure 1. Transformative learning outcomes for sustainability.

Although prior research has studied transformative learning outcomes, their specific nature within sustainability contexts remains under-conceptualised. This study contributes to the literature by advancing a conceptualisation of transformative learning outcomes for sustainability. Further research is needed on the assessment and evaluation of these outcomes.

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LEARNERS' PERCEPTIONS OF DIGITAL TOOL USE IN BUSINESS STUDIES THROUGH DIGCOMP

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Abstract

Digital transformation agendas position digital tools as central to curriculum innovation, yet learners' experiences of these tools in Business Studies remain uneven across socioeconomic contexts. The study reported herein investigated how secondary school learners perceive and experience the use of digital tools in Business Studies, using the European Commission's Digital Competence Framework for Citizens (DigComp) as an analytical lens. A qualitative phenomenological design within an interpretivist paradigm was employed. Focus group discussions and non-participant observations were conducted with eight Grade 10 to 11 learners from two socioeconomically contrasting Johannesburg schools: a quintile 1 township public school and an inner-city independent school. Thematic analysis followed Braun and Clarke's phases and was supported by Atlas.ti. The findings suggest that digital competence is shaped by more than access to devices and connectivity. Four interrelated constructs influenced learners' engagement across the DigComp domains: digital self-efficacy, perceived usefulness of tools for business-related tasks, peer influence, and socioeconomic barriers and opportunities. Learners in the independent school described routine use of collaborative platforms and productivity applications to search for information, co-author tasks, model basic business calculations, and develop multimedia presentations. In contrast, learners in the township school reported intermittent connectivity, restricted time on shared devices, and limited guidance on software use; however, they also demonstrated resourcefulness by relying on peer support and mobile technologies to complete tasks and sustain participation. Across both settings, learners valued digital tools for strengthening conceptual understanding and making Business Studies tasks feel authentic, such as budgeting, market research and business pitches. It is concluded that bridging digital inequities in Business Studies requires both infrastructural support and pedagogical design that explicitly teaches DigComp-aligned practices, including critical information evaluation and digital safety, while building learner agency through structured, collaborative routines that can function in low-connectivity environments.

Keywords: *DigComp, business studies, learner perceptions, digital self-efficacy, digital equity.*

1. Introduction

Business Studies is positioned in the South African school curriculum as a subject that develops entrepreneurial thinking, financial literacy, ethical decision-making and socioeconomic participation (Department of Basic Education (DBE), 2011). These purposes have become more demanding as business practices are increasingly mediated by digital platforms, productivity software and online communication. Learners are expected not only to know business concepts, but also to search for information, evaluate examples, design artefacts, communicate ideas and solve business-related problems using digital tools.

Digital transformation has therefore made digital literacy central to Business Studies education. Digital technologies can support learning when they create opportunities for participation, collaboration and knowledge production (Timotheou et al., 2023; Tinmaz et al., 2022). However, South African learners do not encounter these opportunities under equal conditions. Differences in connectivity, school infrastructure, access to devices, teacher guidance and peer support shape whether digital tools become meaningful learning resources or occasional add-ons to classroom work. This makes learner experience an important entry point for understanding digital integration in Business Studies.

The problem addressed in this paper is that much of the discussion on digital tool integration foregrounds policy, infrastructure and teacher preparedness, while learners' own accounts of how they use and interpret digital tools remain less visible. This is particularly important in subject-specific contexts such

as Business Studies, where digital tools are not neutral technologies but can support market research, budgeting, promotional design, business plans and entrepreneurial identity. Learner creativity is therefore treated in this paper as both the production of digital business artefacts, such as posters, logos, slides and presentations, and the resourceful adaptation of available tools under constrained conditions.

The study uses the Digital Competence Framework for Citizens (DigComp) as a conceptual lens. The framework provides five domains for analysing digital competence: information and data literacy, communication and collaboration, digital content creation, safety, and problem-solving (Carretero et al., 2017; Vuorikari et al., 2022). The paper addresses two focused research questions: How do Grade 10 and Grade 11 learners perceive and experience the use of digital tools in Business Studies across the five DigComp domains? What factors shape learners' creativity, confidence and participation when using digital tools for Business Studies tasks?

2. Literature and conceptual framework

The literature reviewed shows that Business Studies can contribute to social and economic transformation when learners connect classroom concepts with lived economic realities. In the African context, business and management education has also been criticised for importing models without sufficient attention to local socioeconomic conditions (Honig & Hjortsø, 2018). In this study, that concern is extended to digital pedagogy; learners' digital competence cannot be separated from the places, resources and social relationships through which digital learning occurs.

DigComp was appropriate because it moves digital literacy beyond the simple ability to operate devices. The framework attends to how citizens locate and evaluate information, communicate and collaborate, create content, behave safely and solve problems in digital environments (Carretero et al., 2017; Vuorikari et al., 2022). These domains map closely onto Business Studies tasks. For example, learners may search for market information, work with peers on a business plan, create a digital advertisement, protect privacy when sharing work, or use spreadsheets to calculate costs and profit.

The analysis also drew on four constructs that emerged strongly in the project data. Digital self-efficacy explains how learners' confidence shapes persistence and willingness to try unfamiliar tools (Bandura, 1997). Perceived usefulness explains why learners are more willing to adopt a tool when it helps them understand a business task or produce a more meaningful artefact (Davis, 1989). Peer influence explains how classmates become informal mediators of digital learning, especially where formal training is uneven; this is consistent with sociocultural views of learning as socially mediated (Vygotsky, 1978; Wenger, 1998). Finally, socioeconomic barriers and opportunities draw attention to the digital divide as a problem of meaningful use, not only physical access (Warschauer, 2003).

Figure 1 presents the analytical model used. It synthesises the DigComp domains, the sociotechnical mediators identified in the findings, and the Business Studies forms of participation reported by learners.

Figure 1. DigComp-informed sociotechnical model of learners' digital engagement in Business Studies.

DigComp domains		**Sociotechnical mediators**		**Business Studies participation**
• Information and data literacy • Communication and collaboration • Digital content creation • Safety • Problem-solving	→	• Digital self-efficacy • Perceived usefulness • Peer influence • Socioeconomic barriers and opportunities	→	• Market research • Group tasks • Posters, logos and pitches • Ethical participation • Business calculations and solutions

3. Methodology

The study adopted a qualitative phenomenological design within an interpretivist paradigm. Phenomenology was suitable because the purpose was to understand learners' lived experiences of digital tool use from their own perspectives (Moustakas, 1994), while the interpretivist orientation allowed attention to the meanings learners attached to digital participation in different school contexts (Creswell & Poth, 2018).

Participants were eight Business Studies learners in Grades 10 and 11 from two secondary schools in Johannesburg. Four learners were selected from a quintile 1 public school in Alexandra township and four from an independent school in Doornfontein. The public school had limited socioeconomic resources, although it had smartboards and a functional computer laboratory. The independent school had more consistent digital infrastructure and more routine instructional use of technology. Each school contributed two Grade 10 and two Grade 11 learners, with equal gender distribution, and participants were between 16 and 18 years of age.

Participants were purposively selected based on grade level, Business Studies performance, and access to digital tools within the school environment. Data was generated through focus group discussions, non-participant observations and analytic memos. The focus group questions were aligned with the five DigComp domains and asked learners to reflect on information searching, digital collaboration, content creation, digital safety and problem-solving in Business Studies.

Data analysis followed Braun and Clarke's (2006) six phases of thematic analysis: familiarisation, initial coding, searching for themes, reviewing themes, defining and naming themes, and producing the final account. Transcribed focus group data were imported into Atlas.ti to support coding, memoing and organisation of themes. The analysis combined inductive attention to learners' own language with deductive interpretation through the DigComp domains. Trustworthiness was strengthened through triangulation of focus group data, observations and analytic memos, as well as member checking, reflexive journaling and an audit trail of analytic decisions.

Ethical clearance and permissions were obtained through the University of Johannesburg, the Gauteng Department of Education, school principals, participants and guardians. Pseudonyms were used for all learners. Because the study involved only eight learners from two schools, the findings are not generalisable to the population. Instead, the paper offers context-rich insights that may be transferable to similar Business Studies classrooms where digital participation is shaped by unequal resources.

4. Findings and discussion

The findings are organised around the two research questions. First, the discussion presents learners' experiences across the DigComp domains. Second, it examines the factors that shaped creativity, confidence and participation. Table 1 below provides a concise comparative summary before the themes are discussed in detail.

Table 1. Summary of comparative learner experiences across DigComp domains.

DigComp domain	Independent school pattern	Township public school pattern	Creativity and participation insight
Information and data literacy	Learners cross-checked websites and used Google Docs, YouTube and other online resources to make sense of Business Studies content.	Learners waited for laboratory access, relied on phone data, checked the website's appearance, and asked peers to verify information.	Digital information became useful when it clarified business concepts such as demand and supply.
Communication and collaboration	Learners used Microsoft Teams, Google Docs and WhatsApp for routine collaboration and simultaneous editing.	Learners used WhatsApp more often and sometimes sent separate work for one peer to combine because connectivity was uneven.	Online spaces enabled quieter learners to participate and encouraged peer competition to improve slides.
Digital content creation	Learners used Canva, PowerPoint and related tools to design logos, slides and business pitches that felt authentic.	Learners designed posters and presentations, but experienced limited computer time and uneven software guidance.	Creative artefacts helped learners see themselves as capable business participants.
Safety	Learners reported formal teaching on passwords, plagiarism and safer links.	Learners relied more on instinct, deletion of suspicious messages and privacy caution.	Responsible digital participation requires explicit teaching, not only informal caution.
Problem-solving	Learners used Excel and other tools to test business calculations and understand profit changes.	Learners relied on mobile phones, WhatsApp support and peer help when computers were slow or unavailable.	Problem-solving appeared as both the analytical use of tools and innovation under constraint.

4.1. Learners' experiences across the DigComp domains

In the information and data literacy domain, learners value digital tools because they made Business Studies concepts easier to access and understand. Independent school learners engaged in more evaluative searching, including checking whether different websites provided similar information and considering whether online information was current. One learner explained, "I like checking different websites to see if they say the same thing" (Learner F). Township school learners also searched for information, but their practices were shaped by limited data, intermittent Wi-Fi and restricted laboratory time. One learner noted, "Sometimes we have to wait for the lab to open or the Wi-Fi to work" (Learner A). This shows that information literacy was not only a technical matter; it depended on opportunity, confidence and peer support.

In communication and collaboration, the two school contexts differed in the regularity and quality of digital interaction. Independent school learners described routine use of Google Docs, Microsoft Teams and WhatsApp. They valued shared documents because "we can work at the same time without fighting over who writes" (Learner F). Township school learners collaborated more through delayed exchanges, often sending individual pieces of work for one person to combine. However, digital communication still created spaces for participation. One learner said, "I'm usually quiet in class, but when we chat online,

I speak more because no one interrupts me" (Learner D). This indicates that digital participation can support confidence, especially for learners who may not dominate face-to-face classroom talk.

Digital content creation provided the clearest evidence of learner creativity. Learners connected tools such as Canva and PowerPoint with the production of business-related artefacts: logos, posters, slides, advertisements and business plans. Independent school learners experienced these tools as part of ordinary school practice, while township school learners often had to learn through peers and trial-and-error. Yet both groups associated creative digital production with relevance to Business Studies. Learner F stated, "When I designed my business logo on Canva, it felt real, like I was already running a business." Learner D similarly explained, "Even if we don't have much, when I make a poster that looks nice, I feel capable, like I belong in this digital world." These responses show that creativity was linked to identity, belonging and future economic participation.

In the safety domain, learners demonstrated awareness of online risks, but the depth of this awareness varied. Independent school learners were referred to formal instruction on strong passwords, plagiarism, and unknown links. Township school learners tended to rely on more intuitive strategies, such as deleting suspicious messages or avoiding showing their faces online. One learner explained, "I didn't like showing my face. Once it's online, you can't control it" (Learner D). Learners also recognised ethical issues in Business Studies tasks, including plagiarism and respect for others' work. This finding suggests that digital safety cannot be assumed to develop automatically through tool use; it needs explicit teaching and practice.

In the problem-solving domain, learners linked digital tools to analytical thinking and real-world business preparation. Independent school learners described using Excel to complete business calculations and to observe how changes in numbers affected profit. Learner G stated, "When I used Excel to do my business calculations, I saw how small changes affect the profit." Township school learners had fewer opportunities to use such tools consistently, but they demonstrated adaptability by using mobile phones, WhatsApp groups and peer explanations when school computers were slow or unavailable. Learner D explained, "If I can't use the computer, I use my phone to search or type my notes." This suggests that problem-solving in unequal contexts includes both formal analytical tool use and resourceful improvisation.

4.2. Factors shaping creativity, confidence and participation

Four cross-cutting factors shaped learners' digital engagement across the DigComp domains. The first was digital self-efficacy. Learners who felt confident were more willing to experiment, troubleshoot and help peers. Learner F explained, "When I don't know how to do something, I Google it or try different apps until it works." In contrast, low confidence could result in withdrawal. Learner B stated, "When the computer doesn't work, I stop. There's no one to help, and I'm scared I'll break something." This supports Bandura's (1997) argument that self-efficacy influences motivation and persistence.

The second factor was perceived usefulness. Learners were more positive about digital tools when those tools helped them complete authentic Business Studies tasks. PowerPoint and Canva were not valued only because they produced attractive work; learners valued them because they helped business ideas become visible. Learner D explained, "When I made a PowerPoint for my business plan, I actually understood my costs better." This echoes Davis's (1989) view that perceived usefulness influences technology acceptance. In the context of Business Studies, usefulness was strongest when the digital task supported entrepreneurship, marketing, budgeting or problem-solving rather than simply adding a technological requirement.

The third factor was peer influence. Learners repeatedly described classmates as sources of technical help, feedback and encouragement. Peer mediation was evident when one learner joined Google Docs because a friend explained how it worked, and when another learner said, "My friend taught me how to add animations in PowerPoint. Now I'm the one helping others" (Learner C). Peer influence supported creativity because learners exchanged techniques, improved slides, shared links and competed to produce better artefacts. This finding is consistent with Vygotsky's (1978) view that learning is socially mediated and Wenger's (1998) understanding of learning as participation in a community of practice.

The fourth factor was socioeconomic context. Township school learners encountered unstable internet, limited computer access, short laboratory time and uncertainty about technical support. Independent school learners described online work as part of the normal school routine. These differences support Warschauer's (2003) argument that the digital divide is not only about access to devices, but also about meaningful use. Yet the township learners' responses also show that constraint did not remove agency. Learners used phones, shared data, asked peers for help and improvised when formal access failed. In this sense, creativity appeared not only in polished digital products but also in the strategies learners used to remain part of digitally mediated Business Studies learning.

The cultural and contextual meaning of digital participation was also important. For township learners, digital work was associated with catching up, belonging and not being left behind. For independent

school learners, digital work was more normalised and connected to school expectations. These differences indicate that digital literacy in Business Studies is a sociotechnical practice shaped by skill, context and identity. A learner who says that a poster makes them feel capable is not simply commenting on design software; they are describing how digital creation can reposition them as someone who can participate in business ideas and digital futures.

5. Conclusion and recommendations

This paper examined Grade 10 and Grade 11 learners' perceptions and experiences of using digital tools in Business Studies through the DigComp framework. In response to the first research question, learners experienced these tools as useful across the five DigComp domains, although opportunities were uneven. Independent school learners had more stable access to search for information, collaborate, create content, practise safety and solve business-related problems. Township public school learners had less consistent access and guidance, yet still demonstrated resourcefulness through mobile phone use, peer support, and creative adaptation.

In response to the second research question, learners' creativity, confidence and participation were shaped by digital self-efficacy, perceived usefulness, peer influence and socioeconomic conditions. Creativity was evident in business logos, posters, slides and presentations, as well as in how learners worked around constraints. The findings suggest that digital competence in Business Studies is not only a technical skill, but a sociotechnical process that develops when learners have meaningful tasks, peer support, safety guidance and opportunities to connect digital production with business ideas.

Based on these findings, Business Studies tasks should make DigComp competences visible and assessable through market research, budgeting, business plans, promotional design, presentations and ethical online participation. Digital content creation should also strengthen learner creativity, rather than only improving presentation quality. Learners need explicit teaching on information credibility, plagiarism, privacy and digital safety. Schools in resource-constrained communities require support beyond devices, including reliable connectivity, teacher development and low-bandwidth routines for unstable infrastructure. The study is limited by its small sample of eight learners from two Johannesburg schools; therefore, the findings do not claim statistical generalisation. Future research should include larger, more diverse samples, including teachers and school leaders, and examine learner-generated digital artefacts as evidence of agency, confidence, and future economic aspirations.

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GRADE 11 PHYSICAL SCIENCES TEACHERS' EXPERIENCES OF USING PHET SIMULATIONS-ENHANCED INQUIRY-BASED TEACHING OF CHEMICAL CHANGE

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Abstract

This study investigated Grade 11 Physical Sciences teachers' experiences of using Physics Education Technology (PhET) simulation-enhanced inquiry-based teaching of the chemical change concept. The focus on chemical change was motivated by recurring evidence from South African national diagnostic reports, which consistently indicate that learners struggle to explain chemical processes at a sub-microscopic level. Despite the ongoing global advocation of inquiry-based teaching practices for science classrooms, its implementation still remains a challenge. The study sought to explore how teachers utilise PhET simulations to facilitate inquiry-based teaching of chemical change and to identify the contextual factors influencing their implementation of PhET simulation to support inquiry teaching of chemical change. Following the interpretivist paradigm, a qualitative case study design was adopted to conduct this inquiry on four purposively selected Grade 11 Physical Sciences teachers from four secondary schools in the Johannesburg North Circuit, Gauteng. The purposive selection criteria included their experience in teaching chemical change and use of PhET simulations to support inquiry-based teaching. Data was collected through classroom observations and semi-structured interviews. Classroom observations were guided by the FIT:COM framework which focuses on the integration of technology, pedagogy, and learner interaction. The findings revealed that Physical Sciences teachers used PhET simulations primarily to support the visualisation of abstract aspects of chemical change, such as particle rearrangement during reactions, and to structure inquiry-based activities, including Predict–Observe –Explain. Findings from both classroom observations and semi-structured interviews further revealed that simulations supported the identification and addressing of learners' misconceptions, particularly the distinction between physical and chemical change. However, teachers' use of simulations often conformed to teacher-centred instructional approaches, which limited opportunities for learner-centred inquiry and independent exploration. Moreover, contextual factors such as limited technological resources, overcrowded classrooms, unreliable internet, and insufficient training led teachers to adopt teacher-centred approaches. Therefore, the study concludes that while PhET simulations have the potential to support the teaching of chemical change, their effectiveness depends on how they are pedagogically integrated to achieve meaningful conceptual understanding of chemical processes. It is recommended that professional development programmes focus on subject-specific strategies for using simulations in inquiry-based teaching and that schools adopt context-responsive innovations, such as shared-device use and offline simulations, to support implementation in resource-constrained environments.

Keywords: *Chemical change, inquiry-based learning, PhET simulations, technology-enhanced science teaching, teachers' lived experiences.*

1. Introduction

The teaching and learning of chemical change in Physical Sciences continues to present challenges in many South African classrooms. Chemical change is inherently abstract and requires learners to understand processes at a sub-microscopic level, which are not directly observable (Cooper & Stowe, 2018). Year after year diagnostic reports consistently highlights poor learner performance in chemistry-related topics, particularly those involving chemical change (Ramnarain & Penn, 2021). These persistent challenges suggest that traditional teaching approaches are not adequately supporting learners in developing meaningful conceptual understanding (Assem et al., 2023). In response to these challenges, the South African Physical Sciences Curriculum and Assessment Policy Statement (CAPS) Specific Aim 1 advocates for the use of inquiry-based teaching approaches, as it states that one of its aims is to make

learners aware of their environment and equip them with investigative skills relating to physical and chemical phenomena (Department of Basic Education, 2011).

The White Paper 7 on e-Education, a South African policy document posits that technology is essential because it allows teachers and learners to create new ways of gathering, sorting, selecting, and analysing information (Vandeyar, 2015). However, despite these policy expectations, the implementation of inquiry-based teaching supported by technology remains a challenge in many classrooms. A study conducted in a South African classroom show that teachers often struggle to integrate technology meaningfully into inquiry-based teaching due to contextual constraints such as limited resources, inadequate training, and curriculum pressures (Ramnarain, 2020). This study explores teachers' experiences of using PhET simulations to teach chemical change through inquiry-based approaches. s.Despite increasing emphasis on technology integration and inquiry-based teaching in policy and research, there is limited empirical evidence on how Physical Sciences teachers in South African classrooms implement PhET simulations within inquiry-based teaching, particularly when teaching abstract concepts such as chemical change. This gap underpins the need for the present study.

2. Literature review

Inquiry-Based Science Education (IBSE**)** is widely recognised as a key approach within reformed science education curricula, as it promotes active engagement, critical thinking, and the construction of scientific knowledge (Ronnebeck et al., 2016). Within this broader framework, inquiry-based teaching (IBT) refers to the ways in which teachers implement inquiry principles in classroom practice. IBT emphasises the role of the teacher in designing learning experiences that encourage learners to ask questions, investigate phenomena, and construct scientific explanations (Kazeni & Mkhwanazi, 2020; Greenwood et al., 2022).It aligns with the goals of the highly advocated reformed science education curriculum, which emphasises the development of scientific inquiry skills. In the context of Physical Sciences, studies have shown that teachers often struggle to implement IBT effectively, frequently resorting to teacher-centred approaches due to curriculum demands, limited access to technological resources, and lack of pedagogical support (Ramnarain et al., 2020). This highlights a gap between policy expectations and actual classroom practice, particularly in South African contexts. These contextual realities highlight that the challenges associated with integrating technology into inquiry-based teaching are not only pedagogical but also shaped by systemic and structural conditions within the South African education system

Chemical change is one of the concepts that learners find particularly difficult to understand because it requires an understanding of processes that occur at a sub-microscopic level, which cannot be directly observed. This challenge is reflected in South African national diagnostic reports, which consistently indicate that learners struggle to explain chemical processes and to link observable phenomena with underlying particle interactions. Research indicates that these difficulties are often rooted in the way the concept is taught, where instruction tends to focus on symbolic and macroscopic representations without adequately linking them to sub-microscopic processes (Mamombe et al., 2020; Cooper & Stowe, 2018). As a result, learners often develop misconceptions, especially when distinguishing between physical and chemical changes and when explaining reactions in terms of particle interactions (Mamombe et al., 2020). PhET-enhanced inquiry-based teaching has the potential to address these misconceptions by providing interactive and visual representations of scientific phenomena (Wen et al., 2023). PhET simulations allow learners to manipulate variables and observe outcomes, making them particularly suitable for supporting inquiry-based learning. In the context of chemical change, these simulations can support the visualisation of abstract processes such as particle rearrangement during chemical reactions which are not directly observable in traditional classroom settings. When simulations are used within structured approaches such as Predict–Observe–Explain, they can support learners in developing an improved understanding of concepts by encouraging them to make predictions, observe outcomes, and explain their reasoning (Alfiyanti & Jatmiko, 2020; Makamu & Ramnarain, 2022).

3. Theoretical framework

Technological Pedagogical Content Knowledge (TPACK) was selected and deemed suitable for theoretically underpinning this inquiry. The TPACK (Mishra & Koehler, 2006) framework highlights the overlap between the PCK knowledge components of a teacher and the integration of technology to enhance pedagogical practices that will transform and promote enhanced conceptual understanding. The framework highlights the importance of teachers' ability to effectively combine these knowledge domains to enhance teaching and learning in meaningful ways. In the context of this study, content knowledge relates to the teaching of chemical change, a concept that requires learners to understand both observable phenomena

and sub-microscopic processes. Pedagogical knowledge is reflected in the use of inquiry-based teaching approaches, which promote learner engagement, questioning, and conceptual understanding. Technological knowledge focuses on the use of PhET simulations as tools to support the teaching and learning of abstract scientific concepts. The intersection of these knowledge domains is central to effective teaching. Teachers are required not only to understand the content, but also to apply appropriate pedagogical strategies while integrating technology in a way that enhances learning. The TPACK framework therefore provides a useful lens for examining how teachers use PhET simulations to support inquiry-based teaching of chemical change. In this study, the TPACK framework is used to analyse how teachers integrate PhET simulations into their teaching practices, as well as the challenges they experience in doing so. It also allows for an understanding of how contextual factors, such as access to resources and classroom conditions, influence the relationship between technology, pedagogy, and content in real classroom settings.

4. Methodology

This study adopted a qualitative case study design within an interpretivist paradigm to explore Grade 11 Physical Sciences teachers' utilisation and implementation of PhET simulation-enhanced inquiry-based teaching of chemical change. The study aimed to examine how teachers use PhET simulations to support inquiry-based teaching and to identify the contextual factors influencing the implementation of PhET simulation-enhanced inquiry-based teaching of chemical change. The qualitative case study design was considered appropriate as it allowed for an in-depth exploration of teachers' experiences within their real classroom contexts, where the use of PhET simulations and inquiry-based teaching practices are shaped by contextual realities.A purposive sampling was used to select four Grade 11 Physical Sciences teachers from four secondary schools in the Johannesburg North Circuit, Gauteng. The selection criteria included Physical Sciences teachers who were actively teaching chemical change and had prior exposure to PhET simulations. The selection of one teacher per school allowed for the exploration of experiences across different school contexts, including variations in resource availability and classroom conditions. Data was collected in two stages. Firstly, one lesson observation of approximately 45 minutes was conducted per teacher during the teaching of chemical change. Secondly, semi-structured interviews of about 20-30min were conducted with each teacher following the observation to gain more insight into their instructional choices and experiences. Classroom observations were guided by the FIT: COM instrument (Judson, 2006), which focuses on how technology is integrated with pedagogy and content, as well as the nature of learner engagement during instruction. Data was analysed thematically, with with codes generated inductively from both observation and interview data, allowing patterns to emerge across data sources.The data analysis focused on how teachers used PhET simulations during inquiry-based teaching, the strategies they employed, and the challenges they encountered in their specific classroom contexts.

5. Presentation of findings

5.1. Use of PhET simulations to support understanding of chemical change

The findings revealed that teachers used PhET simulations primarily to support the teaching of abstract aspects of chemical change. During lesson observations, simulations were used to demonstrate processes such as particle rearrangement during chemical reactions, allowing learners to visualise changes that are not directly observable. This was evident in both classroom observations and interview data. Teachers indicated that simulations were particularly useful when explaining concepts that are difficult to visualise, such as particle rearrangement during chemical reactions and the distinction between physical and chemical change. During classroom observations, teachers frequently used simulations to demonstrate processes step-by-step, pausing at key moments to emphasise important concepts. This supported learners in linking macroscopic observations to sub-microscopic representations. Teachers further reported that simulations played a role in addressing misconceptions. For example, some learners initially believed that substances disappear during chemical reactions; however, through the use of simulations, they were able to understand that particles are rearranged rather than destroyed.This was also evident during observations where learners were able to describe reactions in terms of particle movement after interacting with the simulation. Teachers also used PhET simulations within structured inquiry-based approaches. In most observed lessons, simulations were integrated into Predict–Observe–Explain (POE) activities, where learners were required to predict the outcome of a reaction, observe the simulation, and explain their findings. This approach encouraged learner participation and created opportunities for addressing misconceptions related to chemical change.

5.2. Types of inquiry supported through simulation use

While PhET simulations were integrated into inquiry-based teaching, the nature of inquiry observed in the classroom was largely structured. Teachers incorporated simulations into activities such as Predict-Observe-Explain; however, these activities were often guided, with teachers directing learners toward specific outcomes. In most cases, learners were not given opportunities to independently manipulate the simulations or explore alternative explanations, which limited the extent of open inquiry. As a result, the use of simulations supported guided inquiry rather than learner-driven inquiry. This suggests that while simulations were aligned with inquiry-based teaching in principle, their classroom implementation reflected a more controlled pedagogical approach.

5.3. Extrinsic factors hindering the implementation of PhET-enhanced inquiry-based teaching

The findings further revealed several contextual challenges that influenced the use of PhET simulations in teaching chemical change. These included large class sizes, unreliable internet connectivity, and insufficient training on integrating simulations into inquiry-based teaching. These challenges were evident in both the observations and interviews, where teachers expressed frustration with technological limitations and the lack of professional development opportunities. Teachers reported that large class sizes made it difficult to manage inquiry-based activities effectively, as teachers had to balance learner engagement with classroom management. Unreliable internet connectivity also disrupted lessons, limiting the consistent use of online simulations. Furthermore, teachers indicated that they had not received sufficient training on how to integrate PhET simulations into inquiry-based teaching. As a result, simulations were often used for demonstration purposes rather than as tools for facilitating enhanced conceptual understanding. As a result, teachers often adopted teacher-centred approaches when using simulations, prioritising classroom control and content coverage over learner exploration. This limited the potential of simulations to fully support inquiry-based learning.

5.4. Summary of key findings

Table 1. Summary of Key Findings on the Use of PhET Simulations.

Theme	Evidence from data	Link to chemical change
Visualisation of abstract concepts	Simulations used to demonstrate particle rearrangement during reactions	Helped learners understand sub-microscopic processes
Use of inquiry strategies	Integration of Predict–Observe–Explain (POE) activities	Supported explanation of chemical vs physical changes
Teacher-directed use	Simulations controlled by teacher and projected to class	Limited learner manipulation of variables
Addressing misconceptions	Classroom discussions revealed confusion between physical and chemical changes	Simulations used to clarify conceptual misunderstandings
Learner engagement	Increased participation during simulation-based lessons	Simulations used to clarify conceptual misunderstandings

6. Discussion

6.1. PhET simulations and conceptual understanding of chemical change

The findings of this study indicate that the use of PhET simulations supported teachers in explaining abstract aspects of chemical change. In this study, simulations were particularly effective in supporting the visualisation of sub-microscopic processes, such as particle rearrangement during chemical reactions. This aligns with existing literature, which suggests that digital simulations can make invisible scientific processes more accessible to learners. Simulations function as cognitive tools that support conceptual understanding by linking macroscopic observations with sub-microscopic representations. Furthermore, the findings showed that simulations assisted in addressing learners' misconceptions, particularly the belief that substances disappear during chemical reactions, by illustrating the rearrangement of particles.

Through the visualisation of sub-microscopic processes, teachers were able to demonstrate particle interactions during chemical reactions, which learners are unable to observe directly. This was evident during lesson observations where learners engaged with explanations of chemical processes at a particle level. The use of structured inquiry approaches, particularly Predict-Observe-Explain, further supported conceptual understanding by encouraging learners to actively engage with the content and reflect on their thinking. This aligns with the principles of inquiry-based learning, which emphasise learner participation

and knowledge construction (Kazeni & Mkhwanazi, 2020; Greenwood et al., 2022). However, the findings also suggest that the effectiveness of simulations is dependent on how they are integrated into teaching. While simulations have the potential to support inquiry-based learning, their use in a teacher-directed approach, in which learners follow prescribed steps rather than exploring independently, limits opportunities for learner exploration and inquiry.

6.2. The influence of context on technology integration

Although PhET simulations were used within an inquiry-based framework, the findings reveal a tension between the intended learner-centred nature of inquiry-based teaching and the teacher-directed manner in which simulations were implemented. In this study, simulations were often used in a structured and guided manner, limiting opportunities for learners to engage in independent exploration and knowledge construction. This suggests that the presence of technology alone does not automatically result in learner-centred pedagogy. This finding is concurring with research indicating that teachers often revert to teacher-centred practices due to contextual pressures. Factors such as time constraints, large class sizes, and curriculum demands influenced how teachers mediated the use of simulations. As a result, the use of simulations tended to support guided inquiry rather than open inquiry, which may limit the development of higher-order thinking skills associated with inquiry-based learning.

The challenges identified in this study reflect broader issues related to technology integration in South African classrooms. Limited access to resources, large class sizes, and unreliable internet connectivity have been widely reported as barriers to effective implementation (Ramorola, 2013). In this study, these factors directly influenced how PhET simulations were used, often resulting in a shift from learner-centred inquiry to teacher-directed instruction. These findings highlight the importance of considering context when integrating technology into teaching and further reinforces the gap between policy expectations, such as those outlined in White Paper 7 on e-Education, and the realities of classroom practice.While policy documents such as CAPS promote the use of inquiry-based approaches, the realities of classroom environments may constrain their implementation. This suggests the need for context-responsive innovations that consider the conditions under which teachers work.

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INITIAL TEACHER EDUCATION AND THE DEVELOPMENT OF INTERCULTURAL COMPETENCE: THE MENTORS' PERSPECTIVE

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Abstract

In a dynamic, multicultural, and inclusive educational environment, the cultivation of intercultural competence within initial teacher education constitutes a central dimension of professional development. Grounded in the ITC model (Dimitrov & Haque, 2016) and Kolb's experiential learning cycle (Kolb, 1984), intercultural teaching competence provides a coherent theoretical framework for strengthening teacher education, particularly within programs oriented toward global engagement and social justice. This study explores mentors' perceptions of existing support, challenges, and developmental opportunities for fostering intercultural competence in initial teacher education. The research tasks were: (1) to examine mentors' experiences working with students from diverse cultural and linguistic backgrounds; (2) to identify challenges in implementing intercultural strategies; (3) to analyze the practices mentors use to support student teachers; and (4) to propose recommendations for improving intercultural approaches in teaching practice and study programs. A qualitative design was employed, using focus group interviews with seven primary school mentors in Serbia. All sessions were audio-recorded in their entirety and subsequently transcribed verbatim. The transcripts excluded references to extra linguistic features. During the coding phase and qualitative data analysis, thematic analysis was employed. A combined abductive coding approach was applied in the process of identifying and developing themes. The findings indicate the presence of two distinct discourses. The first, a humanistic discourse, frames intercultural education primarily as the affirmation and appreciation of diversity, emphasizing the inherent value of cultural plurality. The second, a transformational discourse, rests on the assumption that a culture of coexistence constitutes a dynamic and processual construct, shaped through open dialogue among teachers, students, and parents regarding tensions, inequalities, and challenges.Within these frameworks, mentors identified both effective practices and significant barriers. Effective practices include interactive and participatory methods, group discussions, project-based activities, managing sensitive parental perceptions, and reflective analyses for student teachers during practicum. The main barriers to the implementation of intercultural strategies include the lack of systemic support, limited resources, weak integration of theory and practice, and administrative constraints. The study recommends integrating intercultural content more systematically into teacher education curricula, restructuring practicum and school-based observation, providing continuous professional development for teachers and mentors, strengthening cooperation between schools and faculties of education, and fostering professional communities of practice.

Keywords: *Intercultural education, teacher education, mentors, primary school, diversity*.

1. Introduction

In contemporary educational contexts, increasingly shaped by cultural, ethnic and linguistic diversity, the development of intercultural competence has become a key priority in initial teacher education (UNESCO, 2013). This reality places important responsibilities on future teachers. They need to understand intercultural contexts, respond to the needs of students from diverse backgrounds, promote inclusion and foster intercultural dialogue. It also places responsibility on teacher educators, who design and implement intercultural content and strategies within teacher education programmes. School-based mentors play a particularly important role in this process. During practicum, they directly influence student teachers' professional development by providing support, guidance and models of professional behaviour.

The theoretical framework of this paper is based on the contemporary approach to intercultural competence, more widely known as the ITC Model (Dimitrov & Haque, 2016), and Kolb's model of experiential learning (Kolb, 1984). The ITC Model (Dimitrov & Haque, 2016) represents an important framework for reflection and the enhancement of teaching practice in intercultural university settings. The model comprises 20 competencies organised into three categories: foundational competencies, facilitation competencies and curriculum development competencies. Foundational competencies relate to teachers' self-awareness and the modelling of intercultural competence. Facilitation competencies include communication skills and the encouragement of inclusive interaction with students. Curriculum development competencies refer to adapting teaching to diversity and engaging students in global and socially relevant issues. The model is used as a tool for individual and collective reflection and contributes to the development of inclusive pedagogy, the reduction of prejudice and the strengthening of social cohesion. As a second complementary theoretical framework, Kolb's model of experiential learning (Kolb, 1984) is employed. It consists of four stages: concrete experience, reflective observation, abstract conceptualisation and active experimentation. The model is cyclical and links experience, reflection, theory and practice.

The concept of the teacher as a social agent (Priestley & Drew, 2019; Priestley et al., 2015) further explains how intercultural competence is applied in practice. This is especially visible in mentoring during initial teacher education. Teachers as social agents recognise, interpret and use environmental resources in teaching. These resources include the local community, cultural and social institutions, students' experiences and the digital environment (Hrastinski, 2021). Using such resources helps make intercultural content more concrete. It also supports the global dimension of learning. This encourages student teachers to connect theory with real social contexts (Dzerviniks et al., 2024; Holubnycha et al., 2021). Interaction with people from different cultural backgrounds, as well as analysing real teaching situations, supports reflective learning with mentor guidance. However, research shows that this potential is not always fully realised. The main reasons include limited systemic support, lack of resources and underdeveloped institutional frameworks for intercultural pedagogy (Dimitrov & Haque, 2016).

2. Methods

Although the importance of intercultural competence in teacher education is increasingly recognised in international theoretical and strategic documents (Dimitrov & Haque, 2016; Dzerviniks et al., 2024; UNESCO, 2009, 2013), how this competence is developed in practice—particularly through mentoring—remains insufficiently explored. Questions remain about the extent to which mentors have the capacity to support students in developing intercultural competence, the challenges they encounter, and the strategies they employ when working with students.

This study explores mentors' perceptions of existing support, challenges, and developmental opportunities for fostering intercultural competence in initial teacher education. The research tasks were: (1) to examine mentors' experiences working with students from diverse cultural and linguistic backgrounds; (2) to identify challenges in implementing intercultural strategies; (3) to analyze the practices mentors use to support student teachers; and (4) to propose recommendations for improving intercultural approaches in teaching practice and study programs.

This study was conducted using a qualitative research approach, aiming to gain a deeper understanding of the experiences, perceptions and professional practices of mentors in the context of developing intercultural competence in initial teacher education.

2.1. Participants

Using purposive sampling, the study involved seven teachers from two primary schools in the Zlatibor District of Serbia, all of whom had relevant professional experience working with students from diverse cultural, linguistic and religious backgrounds (Table 1). The selection criteria included: (a) Work experience – both less experienced teachers (up to 5 years) and highly experienced practitioners (over 20 years) were included; (b) Professional status – all participants were actively engaged in mentoring within the teaching bases of the Faculty of Education in Užice; and (c) Diversity of teaching context – they taught in different classes within the first cycle of primary education.

Table 1. Socio-demographic characteristics of the participants (N = 7).

Socio-demographic characteristics	Category	f	%
Gender	Male	2	28,57
	Female	5	71,43
Age	25 – 30	3	42,86
	31– 40	3	42,86
	> 40	1	14,29
Work experience	< 5	2	28,57
	5 –20	2	28,57
	> 20	3	42,86
Grade taught	1st grade	3	42,86
	2nd grade	1	14,29
	3rd grade	1	14,29
	4th grade	2	28,57

2.2. Data collection procedure

Data were collected through focus group interviews. This method allows for the analysis of both individual mentors' perspectives and how these perspectives are shaped through interaction and the collective construction of meaning within a professional community. The focus group interview was conducted as a thematically guided discussion, with four key thematic areas defined in advance in the interview protocol. The discussion covered: (1) mentors' experiences working with students from diverse cultural and linguistic backgrounds, (2) challenges and barriers in implementing intercultural approaches, (3) strategies and forms of support provided to students during teaching practice, and (4) recommendations for improving teaching practice and teacher education programmes. The focus group interview took place in January 2026 and lasted approximately 90 minutes. Two researchers acted as moderators: one primarily guided the discussion, while the other recorded key insights and asked follow-up questions to deepen the responses.

2.3. Data analysis

All data were audio-recorded with participants' prior consent and subsequently transcribed in full. Data analysis was conducted using thematic analysis (Braun & Clarke, 2006). A combined approach to coding was applied: deductive, guided by the research questions and the initial theoretical framework, and inductive, open to patterns emerging from the data. In the initial phase, key segments of text were identified and assigned codes reflecting their meaning. In the next phase, codes were grouped into broader thematic categories that captured the main patterns in mentors' experiences and perceptions. Themes were developed through continuous comparison of data, codes and preliminary interpretations, with ongoing refinement and redefinition of meaning. The analysis considered not only the content of individual statements but also the collective construction of meaning among participants. The final phase involved interpreting the identified themes in relation to the research questions and situating them within relevant literature on intercultural education.

2.4. Research ethics

The study was approved by the Ethics Committee of the Faculty of Education in Užice (Decision no. 2941/1, 29 August 2025). All participants provided informed consent, with a clear explanation of the study's aims, the data collection procedure, and how the data would be used. Participation was voluntary, with the option to withdraw at any time without consequence. Anonymity and confidentiality were ensured, and the data were accessible only to the research team.

3. Results and discussion

The findings reveal two dominant discourses in mentors' understanding of intercultural education, reflecting their prior experiences with students from diverse cultural and linguistic backgrounds: humanistic and transformative (Table 2). The humanistic discourse was represented by 57.14% of teachers, while 42.86% adopted a transformative discourse. Both reflect different levels of conceptualising interculturality. The humanistic discourse focuses on accepting diversity, affirming cultural pluralism, and recognising identity as central to working with students. Mentors often describe everyday situations in which it is necessary to "calm tensions among students from different backgrounds and explain that everyone is equally valued," or note that "in practice, they most often work to teach children not to make distinctions and to respect one another regardless of their background." Their role is oriented towards fostering tolerance among students and parents and raising awareness among peers.The transformative discourse views

interculturality as a dynamic process developed through dialogue, reflection, and co-construction of meaning. Teachers describe situations where "misunderstandings arise due to differing family value systems, which are not ignored but addressed through discussion with students and parents," or highlight that "the greatest learning occurs when conflicts of opinion are not avoided but explored through guided dialogue to understand why participants interpret the same behaviour differently." This discourse involves actively engaging with tensions and misunderstandings and includes students, parents, and teachers in a shared process of understanding, giving intercultural education a broader social dimension.

Table 2. Identified themes on mentors' experiences working with students from diverse cultural backgrounds.

Themes	Category	Codes	Typical Answers
The Humanistic Discourse (N = 4)	Understanding intercultural education	Valuing diversity; affirmation of cultural pluralism; recognition of different identities	"…teaching should be adapted but treat everyone equally." "…it's a constant struggle with others' beliefs; the goal is to reach attitudes of acceptance."
	Pedagogical practices focused on acceptance	Highlighting cultural and other differences; promoting tolerance; sensitisation; supporting students	"…to develop students' awareness of the importance of understanding other cultures." "We talked about holidays; one girl mentioned she celebrates Bajram, so we observed it together and even visited her celebration."
The Transformative Discourse (N = 3)	Interculturality as a process	dijalog; konstrukcija značenja; suočavanje sa izazovima; konfliktne interpretacije situacija	"Parents sometimes create additional problems, as they see everything through the lens of being a minority and feeling disadvantaged. This is a challenge and requires compromise."
	Culture of togetherness	Participation; open communication; reflection	"It is important to involve both parents and students in discussions about differences and challenges."

Regarding barriers to implementing intercultural education, mentors' statements suggest three key obstacles. Most teachers emphasised the structural nature of these limitations. A lack of institutional support was reported by 85.71% of participants, with one noting that "everything depends on the teacher's personal motivation, without systemic support." Administrative constraints and limited time (57.14%) further hinder implementation, with mentors commenting that "there is no space for deeper intercultural discussions because programmes and obligations do not allow it." Limited resources (42.86%) and a weak connection between theory and practice (42.86%) were also highlighted as significant challenges. Mentors observed that "what is learned at university often cannot be applied in the real classroom."

In terms of effective practices and strategies, three main approaches were identified. Teachers indicated that the most effective strategies are those that shift teaching towards participatory and experiential learning models. This view was shared by 85.71% of participants, who emphasised interactive methods, discussions, and project-based learning as key approaches. Mentoring practices, recognised by 71.43% of teachers, focus on reflection and guided analysis during teaching practice. Mentors explained that "it is only through joint analysis of concrete situations that students begin to understand what interculturality means in the classroom." Collaboration with parents (57.14%) was identified as a sensitive but important aspect of preparing future teachers. Mentors highlighted the need for careful communication: "The greatest challenge is when parents hold prejudices that affect the child – we must open the conversation carefully."

Finally, four recommendations were identified to improve both teaching practice and initial teacher education. These emphasise the need for systemic transformation across all stages of teachers' professional development. Integrating intercultural content into curricula was supported by 85.71% of mentors, with the view that "interculturality should not be an add-on but part of every lesson." Restructuring student teaching to focus on experiential learning was suggested by 71.43%, highlighting that "students need to spend more time in the classroom than in theory about the classroom," moving away from the assumption that lesson delivery alone defines practice. Continuous professional development through communities of practice was supported by 57.14%, with mentors noting that "we learn the most from each other when we share real school experiences." Strengthening collaboration between schools, faculties, and local communities was recognised by 28.71% as an important improvement, as without institutional connections, intercultural education remains fragmented and dependent on individual enthusiasm.

4. Conclusions

In the context of the theoretical framework based on the ITC Model (Dimitrov & Haque, 2016) and Kolb's model of experiential learning (Kolb, 1984), the findings indicate that the development of future teachers' intercultural competence occurs through a cyclical interaction of experience, reflection, and pedagogical action. The transformative discourse aligns particularly well with Kolb's learning cycle, as it illustrates how intercultural competence develops through concrete experiences, their reflection, and application in new situations. At the same time, the ITC Model highlights the professional role of mentors as key actors who, through their foundational, facilitation, and curriculum development competencies, shape an intercultural learning environment. These findings confirm that integrating theoretical models with experiential practice is crucial for the sustainable development of intercultural education in higher education.

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INDIGENOUS RESEARCH METHODOLOGIES ADOPTION IN POSTGRADUATE RESEARCH: OPPORTUNITIES AND CHALLENGES

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Abstract

This systematic literature review examines the adoption and utilisation of Indigenous Research Methods (IRMs) in postgraduate research. Although extensive scholarship on Indigenous Knowledge Systems (IKS) has focused on their integration into teaching, pedagogy, curriculum, and policy, far less attention has been given to their use in research methodologies. This imbalance sustains a disconnect between the decolonial aspirations of higher education and the epistemic practices through which knowledge is produced. Despite the cultural relevance and epistemic value of IRMs, their application in postgraduate research remains limited due to structural, ideological, and institutional factors that continue to privilege Western research paradigms. Using the PRISMA approach, the review systematically analysed peer-reviewed journal articles published between 2010 and 2025. Studies were identified, screened, and included based on clearly defined inclusion and exclusion criteria. The review synthesised empirical and conceptual literature to identify dominant patterns, recurring challenges, and gaps relating to the adoption of IRMs in postgraduate education research. The findings indicate persistent barriers to IRM uptake. These include the absence of formal training in IRMs for postgraduate students and supervisors, limited inclusion of IRMs in research methodology curricula and textbooks, inadequate supervisory expertise, and Western-centric examination and peer-review standards that marginalise Indigenous methodologies. Additional constraints include fears of examiner bias and journal rejection, limited funding opportunities for IRM-based research, and the lack of institutional policies that formally support the use of IRMs in postgraduate research. The review recommends embedding IRMs within postgraduate research methodology curricula, strengthening supervisory capacity through targeted training, developing institutional policies and funding mechanisms that support IRM-based research, and broadening research evaluation standards to recognise epistemic diversity. It further calls for empirical studies that evaluate strategies for mainstreaming IRMs in postgraduate programmes.

Keywords: *Indigenous research methods, indigenous knowledge systems, cognitive justice, decolonisation, postgraduate research.*

1. Introduction

Contemporary research involving Indigenous communities remains entangled in colonial legacies that have historically positioned Indigenous peoples as objects of inquiry rather than co-constructors of knowledge. Although there has been a growing shift toward recognising Indigenous Knowledge Systems (IKS) within higher education, this recognition has largely been confined to curriculum and pedagogy (Drawson et al., 2017), with limited transformation in the methodological foundations of research. Scholars such as Datta (2018) and Owusu-Ansah and Mji (2013) argue that meaningful decolonisation requires more than the inclusion of Indigenous content; it demands the centring of Indigenous epistemologies, values, and participatory practices throughout the research process. However, this epistemic shift remains uneven and, in many cases, superficial.

Indigenous Research Methodologies (IRMs) offer a critical pathway for reconfiguring research practices toward more ethical, relational, and culturally grounded approaches (Keane et al., 2017). These methodologies prioritise respect, reciprocity, and active community involvement, aligning with principles of wholism and relational accountability (Pidgeon & Riley, 2021; Drawson et al., 2017). Empirical examples such as storytelling, sharing circles, participatory action research, and the use of cultural artefacts demonstrate the richness and contextual sensitivity of IRMs (Khuphe & Keane, 2017; Pidgeon, 2021). Yet, despite their potential to produce authentic and contextually relevant knowledge, their adoption in postgraduate research remains limited. This paradox reflects a deeper structural tension within academia: while IRMs are theoretically endorsed as tools for decolonisation, institutional practices continue to privilege Western paradigms as the benchmark of methodological rigour and legitimacy (Keane et al., 2017).

This dominance is reinforced through interconnected systems of knowledge production, including research training, supervision, publication, and evaluation. Postgraduate students are often socialised into Western methodological traditions through curricula that marginalise or exclude IRMs (Datta, 2018). At the same time, concerns about examiner expectations, peer-review standards, and publication prospects discourage experimentation with Indigenous approaches (Khuphe & Keane, 2017). Furthermore, IRMs are frequently mischaracterised as simplistic or lacking systematic rigour due to their oral, relational, and context-specific nature (Owusu-Ansah & Mji, 2013). Such perceptions not only undermine their legitimacy but also reproduce epistemic hierarchies that contradict the transformative goals of decolonial research.

The persistence of these constraints reveals a critical misalignment between the stated commitment to decolonising knowledge and the methodological practices through which knowledge is generated. As Drawson et al. (2017) caution, the continued reliance on Western frameworks in studies aimed at challenging coloniality risks reproducing the very forms of marginalisation such research seeks to dismantle. This contradiction is particularly pronounced in postgraduate research, where emerging scholars navigate institutional expectations while attempting to engage with Indigenous epistemologies in meaningful ways. Consequently, the underutilisation of IRMs cannot be understood solely as an individual choice but must be situated within broader structural, ideological, and institutional dynamics.

Against this backdrop, the present study responds directly to the persistent gap between the recognised value of IRMs and their limited application in postgraduate research. It critically examines the opportunities that IRMs present for transforming research practices, alongside the challenges that constrain their adoption. In doing so, the study moves beyond advocacy to interrogate the conditions under which IRMs can be meaningfully integrated into postgraduate research.

The significance of this study lies in its focus on an underexplored dimension of decolonisation—methodological practice. While existing literature has extensively documented the importance of integrating IKS into teaching and learning, far less attention has been given to how research itself can be decolonised through the adoption of IRMs. By synthesising insights on both the enabling and constraining factors, this study contributes to a more nuanced understanding of why IRMs remain marginal despite their recognised value. It further addresses gaps related to the role of postgraduate training, supervisory capacity, and institutional structures in shaping methodological choices. Ultimately, the study provides a basis for rethinking research training, policy, and evaluation in ways that support epistemic plurality and more inclusive knowledge production.

2. Theoretical frameworks

This study is underpinned by the theory of cognitive justice as conceptualised by Visvanathan (1997). Cognitive justice advocates for the recognition and coexistence of multiple knowledge systems, particularly those historically marginalised, such as IKS (Odora-Hoppers, 2021). In the South African context, higher education continues to privilege Western epistemologies, often overlooking Indigenous ways of knowing (Lebowitz, 2017). This creates an epistemic imbalance that extends beyond curriculum content to the methodologies through which knowledge is produced.

Cognitive justice provides a critical lens for understanding the marginalisation of IRMs in postgraduate research. While IKS is increasingly acknowledged, its methodological foundations remain underutilised, reflecting a disconnect between decolonial intentions and research practices. The theory therefore supports the need to align research methods with the nature and context of the research problem, particularly in studies involving IKS (Khuphe & Keane, 2017).

Importantly, this study does not reject Western methodologies but advocates for epistemic pluralism—where IRMs are adopted alongside other approaches when appropriate. Within this framework, the study examines the opportunities and challenges of IRM adoption as expressions of broader epistemic conditions. In doing so, it positions the use of IRMs as essential for advancing inclusive, contextually relevant, and socially just research practices in postgraduate studies.

3. Research methodology

A systematic literature review was conducted to synthesise scholarship on the adoption of IRMs in postgraduate research in a transparent and reproducible manner (Lame, 2019). The review followed the PRISMA framework—identification, screening, eligibility, and inclusion (Nazir & Das, 2025). A comprehensive search was conducted across Google Scholar, Scopus, ProQuest, and ERIC to ensure both breadth and disciplinary relevance. Using predefined keywords and their synonyms, an initial 5,600 records were identified. Following preliminary filtering based on titles and keywords, 65,248 records that did not sufficiently align with the search terms were removed, leaving 2,352 studies for screening.

Clear inclusion and exclusion criteria were established to ensure alignment with the study's focus. The review included peer-reviewed, full-text articles published in English between 2010 and 2025 that explicitly addressed IRMs within postgraduate or higher education research contexts. Studies were excluded if they were non-peer-reviewed, review papers, abstracts or summaries without full text, non-English publications, or unrelated to the study focus. During the screening phase, titles and abstracts of the 5,352 studies were examined, resulting in the exclusion of a substantial number of studies that addressed Indigenous knowledge broadly but did not engage with research methodologies. This process yielded 168 studies for full-text assessment.

In the eligibility phase, the full texts of the 168 articles were critically examined, focusing on their aims, methodological approaches, and relevance to IRM adoption. This stage resulted in 15 studies meeting all inclusion criteria. To enhance comprehensiveness, an ancestral search was conducted by reviewing reference lists of the selected studies, leading to the identification of five additional relevant articles. This brought the final sample to 20 studies included in the review.

To ensure methodological rigour and reliability, the author independently conducted the screening and coding processes using the predefined criteria. A pilot coding exercise was first undertaken to refine the review instrument and ensure consistency. Thereafter, the author applied the criteria, and results were analysed. These procedures strengthened the transparency, consistency, and trustworthiness of the review process, ensuring a robust and credible synthesis of the literature.

4. Research findings

The systematic literature review identified and analysed 30 publications examining the adoption of IRMs in postgraduate research. The findings are presented in two interrelated sections: (1) The opportunities associated with the adoption of IRMs and (2) The challenges constraining their adoptions. The following sections provide a critical synthesis of these findings.

4.1. Opportunities associated with the adoption of IRMs in postgraduate research

The review reveals that IRMs offer significant opportunities for transforming postgraduate research by advancing epistemic inclusion and relational modes of knowledge production. Across the literature, IRMs are consistently positioned as approaches that shift research from extractive practices toward collaborative, participatory, and contextually grounded processes (Chilisa, 2012; Kovach, 2010; Koster et al., 2012). This shift is not merely methodological but epistemological, as it repositions Indigenous communities from passive subjects to active knowledge holders and co-creators. Studies emphasise that such engagement enhances the authenticity and cultural relevance of research, ensuring that knowledge produced resonates with community realities and priorities (Datta, 2018; Owusu-Ansah & Mji, 2013).

A recurring insight is the centrality of relationality in IRMs. Methods such as storytelling, talking circles, and community-based participatory approaches foreground dialogue, trust, and reciprocity, thereby strengthening the ethical foundations of research (Drawson et al, 2017; Galla & Goodwill, 2017). These approaches align with Ubuntu-informed perspectives, which emphasise interconnectedness and collective meaning-making (Bhuda & Marumo, 2022; Seehawer, 2023). In this sense, IRMs extend beyond data collection techniques to embody value systems that prioritise respect, responsibility, and mutual benefit. This orientation contributes to more socially responsive research practices and facilitates the preservation and validation of IKS within academic spaces (Odora-Hoppers, 2021; Mkhwebane, 2024).

Importantly, the literature also highlights the adaptability of IRMs within contemporary research contexts. Rather than existing in isolation, IRMs can be integrated with or inform conventional qualitative approaches, creating hybrid methodologies that remain contextually sensitive while meeting academic expectations (Simonds & Christopher, 2013; Keikelame & Swartz, 2019). This flexibility expands methodological possibilities for postgraduate researchers and supports epistemic pluralism. Collectively, these opportunities position IRMs as critical tools for advancing decolonial research agendas and fostering more inclusive and contextually meaningful knowledge production.

4.2. Challenges constraining the adoption of IRMs in postgraduate research

Despite their transformative potential, the adoption of IRMs in postgraduate research remains constrained by entrenched structural and epistemic barriers. A dominant theme across the literature is the continued privileging of Western research paradigms within higher education institutions (Datta, 2018). These paradigms are reinforced through research training, supervision, and evaluation systems that define methodological rigour in narrowly Western terms (Keane et al, 2017; Khupe & Keane, 2017). As a result, postgraduate students are often socialised into conventional methodological frameworks, with limited exposure to or support for IRMs (Pidgeon & Riley, 2021).

This institutional bias is further compounded by publication and validation systems that marginalise Indigenous approaches. Studies indicate that academic journals and peer-review processes frequently perceive IRMs as lacking systematic rigour due to their oral, relational, and context-specific nature (Owusu-Ansah & Mji, 2013). Such perceptions create a climate of uncertainty, where postgraduate researchers may avoid IRMs due to concerns about examiner bias, publication prospects, and academic credibility (Keane et al., 2017). This reflects a broader epistemic tension, where Indigenous methodologies are acknowledged in principle but remain undervalued in practice.

The review also identifies gaps in institutional support as a significant barrier. There is limited inclusion of IRMs in research methodology curricula, alongside a lack of supervisory expertise to guide students in applying these approaches effectively (Datta, 2018; Pidgeon & Riley, 2021). Furthermore, the absence of clear policies and frameworks supporting IRM-based research contributes to their marginalisation, leaving students to navigate these approaches without adequate guidance (Keane et al., 2017). This lack of structural support reinforces the dominance of Western methodologies and constrains methodological innovation.

When analysed closely, these challenges reflect ongoing epistemic injustice within academia. As Morgensen (2012) and Odora-Hoppers (2021) suggest, the marginalisation of IRMs is not incidental but embedded within the historical and institutional fabric of the academy. Consequently, the underutilisation of IRMs cannot be reduced to individual choice; it is shaped by systemic conditions that regulate what counts as legitimate knowledge and method. Addressing these barriers therefore requires not only increased awareness but structural transformation in research training, supervision, and evaluation practices.

5. Implications, recommendations and conclusions

The findings of the study indicate that while IRMs are widely recognised for their potential to advance decolonial and culturally responsive research, their actual use in postgraduate research remains limited and largely superficial. Postgraduate researchers continue to rely predominantly on Western methodological frameworks, often due to institutional expectations, limited training, and concerns about academic legitimacy. This results in a partial and inconsistent integration of IRMs, which undermines the broader goal of epistemic justice in research practices and restricts the transformation of knowledge production in higher education.

The findings suggest that meaningful adoption of IRMs requires more than theoretical acknowledgement; it demands structured methodological support within postgraduate training programmes. This includes the deliberate inclusion of IRMs in research methodology curricula, targeted supervisory development, and the creation of academic environments that validate diverse epistemologies. In addition, institutional and publication systems need to be more open to evaluating research quality beyond Western-centric standards. Collaboration with Indigenous knowledge holders is also essential to ensure that IRMs are applied authentically and ethically, rather than symbolically or selectively.

In conclusion, the study demonstrates that without deliberate institutional transformation and sustained methodological support, the adoption of IRMs in postgraduate research will remain constrained and inconsistent. This limits the potential for genuine decolonisation of research practices and perpetuates epistemic imbalance in knowledge production. Strengthening postgraduate training, supervisory capacity, and institutional policy support is therefore essential for enabling meaningful, contextually grounded, and epistemically just research practices.

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EDUCATIONAL DECISION-MAKING IN CONTEXTS OF INEQUALITY: A DATA ANALYSIS OF THE GAP BETWEEN POVERTY AND ACADEMIC SUCCESS

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Abstract

The expansion of online learning in emerging economies has intensified interest in the structural determinants of student persistence. This study investigates how district-level socioeconomic configurations relate to academic risk among 3,678 students enrolled in a virtual technology program in Bogotá, Colombia. Using a cross-sectional design that integrates academic records with district-level monetary poverty rates and Gini coefficients across 19 localities, weighted Pearson correlations reveal a counterintuitive paradox: monetary poverty shows a weak, non-significant correlation with academic risk ($r = 0.157$; $p = 0.53$), whereas the local Gini coefficient exhibits a strong negative correlation ($r = -0.647$; $p < 0.01$). Low-income students in high-inequality, socioeconomically mixed localities show success rates approximately three times higher than comparable peers in homogeneously poor peripheral localities. Drawing on theories of urban opportunity structures, social capital, and the digital divide, we interpret the Gini coefficient as a proxy for access to opportunity infrastructure. Findings suggest that territorial interventions targeting digital infrastructure may be more effective for student retention than individual-level income support alone.

Keywords: *Educational data mining, urban inequality, student persistence, digital divide, evidence-based policy.*

1. Introduction

The global expansion of virtual and hybrid education has opened pathways for populations historically excluded from formal learning. In Colombia, virtual technological programs have been promoted as a mechanism to broaden access and reduce persistent inequalities in human capital formation (MEN, 2022; UNESCO, 2021). However, expanded access does not automatically translate into academic success: retention remains a critical challenge, particularly among economically precarious students (Tinto, 1987; Bean & Metzner, 1985).

Educational policy has long emphasized household income as the primary predictor of dropout risk, guiding interventions toward scholarships and emergency economic support. While legitimate, this approach may overlook a more complex constellation of structural factors rooted in the urban environment. Bogotá's 19 administrative localities exhibit profound socioeconomic heterogeneity, ranging from consolidated urban core zones with dense service infrastructure to peripheral localities characterized by concentrated poverty and limited public investment (Castells, 1996; Secretaría Distrital de Planeación, 2022).

This study examines whether district-level socioeconomic indicators—monetary poverty rates and income inequality as measured by the Gini coefficient—predict academic persistence in a virtual program, challenging the assumption that individual-level financial hardship is the dominant territorial predictor of student dropout.

2. Theoretical framework

This study draws on four interconnected bodies of literature. First, student persistence theory highlights that structural and contextual variables—not only individual motivation—condition academic retention (Tinto, 1987; Bean & Metzner, 1985; Romero & Ventura, 2020). Second, urban opportunity structures theory posits that residential location shapes consequential access to resources: neighborhoods of concentrated poverty limit access to quality infrastructure, social networks, and professional role

models—a condition of "double disadvantage" (Wilson, 1987; Massey & Denton, 1993)—while socioeconomically heterogeneous environments may offer protective effects through social mixing (Musterd & Andersson, 2005; Atkinson & Kintrea, 2000).

Third, digital divide scholarship has evolved beyond binary access to encompass quality of connectivity and the availability of complementary public digital infrastructure (Van Dijk, 2006; Warschauer, 2003). Peripheral urban localities suffer a "digital desert" effect: even if households possess basic internet access, the density of public Wi-Fi, libraries, and community digital spaces is substantially lower than in economically dynamic central areas (Graham & Marvin, 2001; CEPAL, 2021). For students in fully virtual programs, this spatial inequality in infrastructure may be decisive. Fourth, agglomeration effects and social capital theory suggest that economically diverse localities generate positive externalities including bridging social capital (Putnam, 2000), knowledge spillovers, and shared infrastructure (Glaeser, 2011) that may partially offset material disadvantages for low-income residents.

3. Methodology

This study employs a cross-sectional correlational design (Creswell & Creswell, 2018). Administrative academic records of 3,678 students enrolled in a public virtual technology program in Bogotá (2022–2023) were integrated with district-level socioeconomic indicators from DANE and the Secretaría Distrital de Planeación. The unit of analysis is the locality; student-level data are aggregated to produce district-level academic risk rates.

The dependent variable is the academic risk rate per locality (proportion of students who failed or withdrew). Independent variables are: (1) district monetary poverty rate (percentage below the poverty line, per DANE); and (2) district Gini coefficient (income inequality within the locality). Socioeconomic stratum (1–6) was used for subgroup analysis. Weighted Pearson correlation coefficients were computed using locality population share as weight, with sensitivity analyses excluding localities with minimal samples (Sumapaz, n = 2; La Candelaria, n = 7) to ensure statistical reliability.

4. Results

4.1. Descriptive overview

Table 1 presents the distribution of students, academic risk rates, and socioeconomic indicators for the 12 most representative localities ($n \geq 50$), covering 93% of total enrollment. Academic risk rates range from 25.5% (Santa Fe) to 57.9% (Rafael Uribe Uribe). A visual inspection suggests that localities with higher Gini coefficients—Santa Fe (0.65), Usaquén (0.54), Suba (0.56)—tend to exhibit lower risk rates, while low-Gini peripheral localities—Usme (0.42), Ciudad Bolívar (0.47)—show higher rates. No equivalent directional pattern is apparent for monetary poverty.

Table 1. Distribution of Students, Academic Risk, and Socioeconomic Indicators by Locality ($n \geq 50$).

Locality	n	Risk %	Gini	Poverty %
Santa Fe	51	25.5	0.65	47.7
Usaquén	137	32.8	0.54	16.0
Fontibón	191	40.8	0.49	19.8
San Cristóbal	248	43.5	0.45	48.5
Bosa	473	47.1	0.46	53.2
Engativá	486	47.5	0.47	24.9
Kennedy	612	47.7	0.50	37.0
Suba	584	50.9	0.56	25.8
Tunjuelito	102	51.0	0.48	40.2
Usme	231	52.4	0.42	57.8
Ciudad Bolívar	359	54.0	0.47	57.4
Rafael Uribe	190	57.9	0.50	50.0

Note. Sorted by academic risk rate (ascending). Gini: district income inequality coefficient. Poverty %: population below the monetary poverty line. Source: DANE & Secretaría Distrital de Planeación (2022); institutional academic records.

4.2. Correlation analysis

The weighted Pearson correlation between district monetary poverty rate and academic risk was $r = 0.157$ ($p = 0.53$)—weak and statistically non-significant, consistent across sensitivity analyses. By contrast, the correlation between the district Gini coefficient and academic risk was $r = -0.647$ ($p < 0.01$)—strong, negative, and statistically significant. Localities with greater income heterogeneity are associated with substantially lower academic risk rates. Subgroup analysis of strata 1–2 students (62% of the sample) confirms that this relationship is most pronounced among low-income students: a student in stratum 1 or 2 residing in a high-Gini, socioeconomically mixed locality shows an academic success rate approximately three times higher than a comparable peer in a low-Gini, homogeneously poor peripheral locality.

5. Discussion

The absence of a significant correlation between monetary poverty and academic risk challenges the prevailing policy assumption that aggregate poverty rates are reliable territorial predictors of educational disadvantage. The strong negative Gini-risk correlation, by contrast, supports a reading of urban inequality that foregrounds socioeconomic heterogeneity as a structural resource rather than a liability.

We interpret this pattern through the concept of urban opportunity infrastructure (Wilson, 1987; Massey & Denton, 1993). In Bogotá, high-Gini localities—such as Santa Fe, Usaquén, and Suba—are typically more central and functionally diverse, with greater density of public libraries, transportation networks, and digital access points. Even low-income students in these localities may benefit from proximity to resources that support virtual learning: stable connectivity, physical study spaces, and community digital infrastructure. This is consistent with the "digital desert" framework (Warschauer, 2003; Graham & Marvin, 2001): peripheral, low-Gini localities in Bogotá are not only economically disadvantaged but informationally isolated—a condition that compounds constraints on academic engagement beyond what household income alone can explain.

The social capital dimension is equally relevant. Drawing on Putnam (2000), socioeconomically diverse localities may facilitate bridging social capital networks that provide low-income students access to varied information, informal mentoring, and peer learning unavailable in more homogeneous environments. Agglomeration effects in economically dense districts may additionally generate educational externalities that benefit all residents (Glaeser, 2011). Together, these mechanisms suggest that the Gini coefficient functions as an indirect indicator of the socioeconomic complexity and infrastructural density of the urban environment—what we term the "infrastructure of opportunity."

Several limitations warrant acknowledgment. The ecological correlation design precludes individual-level causal inference, and the cross-sectional approach limits temporal conclusions. The Gini coefficient may capture sources of variation beyond income heterogeneity—including urban primacy and political economy of public investment—that future research should disentangle.

6. Conclusions

This study provides empirical evidence that district-level income inequality is a stronger predictor of academic persistence than aggregate poverty rates among students in a virtual technology program. These findings have concrete implications for educational policy. Individual-level economic interventions, while necessary, are insufficient as the sole retention mechanism. Complementary territorial strategies should target digital infrastructure investment in peripheral localities, the expansion of community learning spaces with reliable connectivity, and the integration of educational support into neighborhoods affected by spatial isolation and digital scarcity.

More broadly, findings support the incorporation of district-level Gini coefficients and poverty maps into institutional early warning systems, and advocate for cross-sectoral coordination between education and urban development policy. Addressing the "digital desert" effect in Bogotá's peripheral localities requires not only educational investment but urban infrastructure planning that ensures equitable distribution of digital resources. These conclusions apply, with contextual adaptation, to other cities in Latin America and emerging economies where virtual education expansion is occurring against a backdrop of uneven urban development.

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TEACHERS' PEDAGOGICAL PRACTICES WHEN USING INTERACTIVE WHITEBOARDS FOR INTEGRATING INDIGENOUS KNOWLEDGE IN LIFE SCIENCES TEACHING

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Abstract

This study investigated Life Sciences teachers' pedagogical practices when using interactive whiteboards (IWBs) to integrate indigenous knowledge (IK) in Grade 11 teaching and learning. Guided by Cognitive Justice and the Cognitive Theory of Multimedia Learning (CTML), the study adopted a qualitative research design. 10 Life Sciences teachers were purposively selected from schools implementing IWBs in Johannesburg and Ekurhuleni metropolitan municipalities in Gauteng province of South Africa. Data were collected through classroom observations guided by the Reformed Teaching Observation Protocol (RTOP). The study addressed the research question: What pedagogical practices are employed by Life Sciences teachers when integrating IK using IWBs? Data were analysed thematically, allowing themes to emerge from the dataset. Findings revealed that although teachers valued the integration of IK using IWBs, their pedagogical practices were largely limited to displaying static images and videos rather than utilising interactive features to support meaningful engagement with IK. Additionally, teachers experienced challenges including limited IK-aligned digital resources, technical and infrastructural constraints and this showed lack of insufficient professional development. These challenges restricted the effective pedagogical use of IWBs for culturally responsive teaching. As such, this study recommends ongoing professional development focused on pedagogical integration of IK using IWBs, the development of IK-specific digital resources compatible with IWBs, and improved school infrastructure. Notably, the study was limited to a small qualitative sample within one province, which restricts generalisability. Therefore, future research should include multiple provinces and examine the influence of IK integration using IWBs on learner engagement and academic performance.

Keywords: *Life Sciences, qualitative research, cognitive justice, interactive whiteboards, indigenous knowledge.*

1. Introduction

The transformation of education in South Africa has renewed debates about what knowledge should be taught, whose knowledge should be recognised, and how such knowledge should be taught in classrooms. During the era of colonialism and apartheid, the education system largely privileged Eurocentric knowledge systems while marginalising African indigenous ways of knowing (Ndlovu-Gatsheni, 2013). In the democratic era, curriculum reforms were introduced that sought to address these injustices by promoting inclusive and contextually relevant education. Consequently, teachers were mandated through Curriculum and Assessment Policy Statement (CAPS) document to integrate Indigenous Knowledge (IK) into teaching and learning for curriculum decolonisation, particularly in Life Sciences (Department of Basic Education [DBE], 2011; Mavuru, 2025).

Life Sciences is a key subject through which learners engage with critical topics such as biodiversity, heredity, health and environmental sustainability. However, the subject is often taught through abstract and textbook-centred approaches that appear distant from learners' everyday experiences (Mkhwebane, 2024). Such approaches may reduce learner participation and make scientific concepts difficult to understand (de Beer & Whitlock, 2009). Therefore, integrating IK can address this challenge by linking scientific concepts to local practices, community experiences and culturally familiar examples (Mkhwebane et al., 2025 & Patel et al., 2026). Studies indicate that IK integration can improve relevance, motivation and conceptual understanding while also preserving valuable community knowledge systems (Kalolo, 2015; de Beer, 2019; Selepe et al., 2022). Despite these benefits, the classroom integration of IK remains inconsistent and frequently superficial (Cronje et al., 2015). Teachers often refer to IK through isolated examples rather than embedding it meaningfully into pedagogical practices such as inquiry, discussion, comparison of knowledge systems and learner-centred activities (Cronje et al., 2015; Sitsha, 2023). This suggests that the challenge is not merely the inclusion of IK in policy, but how teachers pedagogically implement it in practice.

Alongside curriculum transformation, South African schools have increasingly adopted digital technologies such as Interactive Whiteboards (IWBs) to improve teaching and learning. IWBs enable the use of text, images, video, annotation and interactive tasks, thereby creating opportunities for multimodal and learner-centred pedagogy (Mihai, 2020). In science education, these affordances are significant because they can assist teachers to explain complex or abstract biological processes and enhance learner engagement (Mokoena et al., 2021; Onder & Halil, 2016). Although IK integration and IWB use are often discussed separately, their intersection offers important pedagogical possibilities. Teachers can use IWBs to display indigenous plants, compare indigenous and scientific explanations, annotate cultural case studies, and facilitate learner presentations based on community knowledge.

In this way, IWBs may serve as a bridge between local knowledge and formal science learning while supporting culturally responsive pedagogy. However, the availability of IWBs does not automatically lead to effective teaching. Evidence suggests that teachers often use IWBs for projecting static notes, images or videos rather than using their interactive functions to deepen learning (Mihai, 2020). At the same time, limited research has examined how Life Sciences teachers use IWBs specifically to integrate IK in classroom practice. Consequently, little is known about the pedagogical practices teachers employ to promote meaningful engagement, and the challenges teachers experience when combining technology with IK integration. The problem addressed in this study, therefore, is the limited understanding of Life Sciences teachers' pedagogical practices when using IWBs to integrate IK in teaching and learning. As such this study investigated pedagogical practices employed by Life Sciences when using IWBs to integrate IK in teaching and learning.

2. Theoretical frameworks

This study was guided by Cognitive Justice and the Cognitive Theory of Multimedia Learning (CTML) developed by Visvanathan (1997) and Mayer (1997), respectively. On one hand, according to Visvanathan (1997) Cognitive Justice promotes the recognition and coexistence of multiple knowledge systems rather than privileging Western knowledge alone. In the South African context, Life Sciences has historically marginalised indigenous ways of knowing in favour of Eurocentric perspectives, thereby limiting epistemic inclusion and disadvantaging learners whose cultural knowledge is excluded (Odora-Hoppers, 2021; Lebowitz, 2017). Applied to this study, Cognitive Justice provides a lens for understanding the importance of integrating IK into Life Sciences teaching and learning as a means of promoting socially just, inclusive and contextually relevant pedagogy.

On the other hand, CTML explains that learners understand more effectively when information or content knowledge is presented through coordinated verbal and visual channels (Mayer, 2024). CTML is based on the principles of dual channels, limited cognitive capacity and active processing. This means learners learn better when they actively engage with well-designed multimedia resources that reduce overload and support meaning-making (Mihai, 2020). In this study, IWBs are relevant because they allow teachers to combine text, images, videos, sound and diagrams when teaching complex Life Sciences concepts and integrating IK.

The two frameworks complement each other in the current study. Cognitive Justice advocates that IK should be integrated by valuing marginalised knowledge systems, while CTML asserts that ICT tools such as IWBs can be pedagogically used to support meaningfully integration of IK through interactive and multimodal teaching. Together, these frameworks enabled the study to investigate how teachers use IWBs not only as technological devices, but as pedagogical tools for meaningful, inclusive and engaging integration of IK in Life Sciences teaching.

3. Research methodology

The current study adopted a phenomenological qualitative case study design (Creswell & Creswell, 2018) to investigate the pedagogical practices employed by Life Sciences when using IWBs to integrate IK in teaching and learning. This design was deemed suitable for exploring classroom pedagogical practices within real-life teaching contexts and as experienced by teachers. Through purposive sampling (Cohen et al., 2017), ten Grade 11 Life Sciences teachers were selected from schools in the Johannesburg and Ekurhuleni metropolitan municipalities in Gauteng Province that were equipped with functional IWBs. Participants were required to have a minimum of two years' teaching experience and active use of IWBs in Life Sciences classrooms.

Data were collected and generated primarily through classroom observations, with two lessons observed for each participating teacher. All teachers taught cellular respiration, a complex and abstract topic in Life Sciences. Observations were guided by the Reformed Teaching Observation Protocol (RTOP) as developed and validated by Sawada et al. (2000), which enabled the researchers to examine learner-centred teaching practices, classroom interactions, instructional strategies and the pedagogical use of IWBs during IK integration. Field notes were also used to capture contextual details and critical incidents that occurred during lessons.

Data were analysed thematically using Braun and Clarke's (2006) six-step approach. This process involved familiarisation with the data, generation of initial codes, searching for themes, reviewing themes, defining themes and producing the report. Thematic analysis enabled the identification of recurring patterns related to teachers' pedagogical practices, opportunities and constraints in using IWBs for IK integration.

To ensure trustworthiness, the study considered credibility, dependability, confirmability and transferability. Ethical principles were strictly observed. Ethical clearance (Sem-1-2024-084/10 May 2024) was obtained from the relevant university ethics committee prior to data collection. Participation was voluntary, informed consent was secured from all participants, and anonymity was upheld to protect the selected teachers' identities and confidentiality.

4. Research findings

Lesson observations were analysed using the RTOP to investigate teachers' pedagogical practices when using IWBs to integrate IK in Life Sciences teaching and learning. Findings are presented according to key RTOP dimensions: lesson design and implementation, content knowledge, classroom culture, and technology-mediated learning.

4.1. Lesson design and implementation

Observed lessons showed that teachers attempted to align IWB use with curriculum objectives by incorporating the CAPS-recommended example of traditional beer fermentation when teaching cellular respiration. Most teachers used PowerPoint slides, images and short videos to illustrate fermentation processes. This suggests that teachers recognised the curriculum value of integrating IK and attempted to connect scientific concepts with learners' socio-cultural experiences.

However, lesson design remained largely teacher-directed and transmissive. IWBs were mainly used for presentation rather than for inquiry, collaborative tasks or problem-solving. Learners were seldom invited to analyse, question or extend the indigenous examples presented. For instance, although images of traditional beer production were displayed, teachers rarely asked learners to compare traditional fermentation methods with scientific explanations or to share community-based knowledge. These findings confirm concerns raised in the literature that IK is often included superficially as an "add-on" rather than embedded meaningfully into pedagogy (Cronje et al., 2015; Sitsha, 2023). From a Cognitive Justice perspective, IK was acknowledged but not sufficiently positioned as a legitimate source of classroom knowledge. From a CTML perspective, multimedia tools were used, but mostly for passive viewing rather than active processing of information.

4.2. Content knowledge and conceptual understanding

Teachers generally demonstrated sound subject knowledge of cellular respiration and correctly linked fermentation to anaerobic respiration. Lessons covered core CAPS concepts, indicating adequate disciplinary understanding. The integration of traditional beer brewing enabled some learners to relate abstract biochemical processes to familiar cultural practices. One learner's reference to family brewing practices illustrated how IK can support contextualised meaning-making. This finding aligns with previous studies showing that IK can make science concepts more accessible and relevant to learners lived realities (Kalolo, 2015; de Beer, 2019). It also supports the study's background argument that Life Sciences concepts are often perceived as abstract unless linked to local contexts. Nevertheless, teachers relied heavily on a

single IK example—traditional beer fermentation. Broader indigenous examples related to food preservation, medicinal processes or ecological knowledge were absent. This narrow use of IK limited opportunities for deeper conceptual comparisons and broader epistemic engagement.

4.3. Classroom culture and learner participation

RTOP observations also revealed limited learner agency during lessons. Classroom interactions were dominated by teacher explanations, while learners mostly listened, responded briefly, or copied notes. Learners were rarely given opportunities to operate the IWB, present ideas, or co-construct knowledge using technology. Although some teachers asked factual questions, few tasks promoted higher-order thinking, debate or learner-led inquiry. This indicates that the classroom culture remained predominantly teacher-centred despite the presence of interactive technology. Such findings echo literature arguing that access to technology alone does not transform pedagogy unless accompanied by learner-centred instructional practices (Mihai, 2020; Mokoena et al., 2021).

4.4. Technology-mediated learning

The IWB was primarily used as a display tool for slides, static images and videos. Its interactive functions—annotation, manipulation of objects, collaborative writing, simulations or learner-led presentations—were rarely utilised. Learners did not use technology for inquiry, data gathering, problem-solving or creative production. This suggests that while teachers valued IWBs, they lacked pedagogical strategies for meaningful technology integration. In terms of CTML, the presence of multimedia alone was insufficient. Effective multimedia learning requires active engagement, integration of visual and verbal information, and reduced cognitive overload (Mayer, 2024). Since lessons remained presentation-based, the pedagogical affordances of IWBs were not fully realised.

5. Implications, recommendations and conclusions

The study showed that although teachers value integrating IK using IWBs, their practices remain largely limited to displaying static images and videos rather than using interactive features for meaningful engagement. Teachers face challenges such as limited IK-aligned resources, inadequate training, and technical constraints, which result in superficial integration of IK and continued teacher-centred approaches in Life Sciences. This hinders learner engagement, weakens conceptual understanding in Life Sciences, and limits the potential of IWBs to support culturally responsive pedagogy.

The findings imply that meaning IK integration requires targeted professional development focused on pedagogical use of IWBs, development of IK-specific digital resources, and stronger technical and infrastructural support in schools. It also highlights a need for Professional Learning Communities (PLCs) and collaboration with IK holders to strengthen authentic integration.

In conclusion, the study reveals that without adequate support, IK integration using IWBs will remain superficial and underutilised, limiting both curriculum transformation and learner engagement in Life Sciences. Strengthening teacher capacity and institutional support is essential for achieving meaningful, technology-enhanced, and culturally responsive science education.

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DEGROWTH PEDAGOGY IN MANAGEMENT AND BUSINESS EDUCATION

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Abstract

This study addresses the research question of what constitutes the fundamental elements of degrowth pedagogy in management and business education, and how are these elements manifested across the micro, meso and macro levels. The analysis is based on an integrative literature review (n=15). The findings suggest that degrowth pedagogy is inherently oppositional and defines itself through resistance. Specifically, the study identifies the following fundamental elements of degrowth pedagogy: (1) ecocentrism and ecological literacy; (2) an understanding of the historical, value-laden and political nature of social systems; (3) critical thinking and questioning; (4) multi-paradigmatic thinking and imagination; (5) dialogue and reflection; (6) experiential and transdisciplinary learning contexts; and (7) conviviality, care and emancipatory capacities. Resistance to the growth paradigm, alongside the thinking and enactment of degrowth, emerges as a cross-cutting theme. Degrowth pedagogy remains an emerging field of study, and its relationship to related educational perspectives warrants further elaboration.

Keywords: *Degrowth, post-growth, pedagogy, management and business education, integrative review.*

1. Introduction

No evidence has been found of an absolute, sufficiently rapid, and sustained global decoupling of environmental harms from economic benefits of the kind required for ecological sustainability (Vadén et al., 2020). Consequently, the principal problem associated with perpetual economic growth lies in its inherent unsustainability (Toikka et al., 2026). The concept of degrowth challenges the dominant paradigm of green or sustainable growth by advocating political and social transformation aimed at reducing a society's throughput – that is, the flows of energy and resources into and out of the economy – while improving quality of life (Kallis et al., 2018). Degrowth is grounded in the principles of anti-capitalist thought, democratisation, justice, conviviality, sufficiency, and care (Levelt et al., 2026) and its policy proposals support three broad goals: reducing the environmental impact of human activities; redistributing income and wealth both within and between countries; and promoting the transition from a materialistic to a convivial and participatory society (Cosme et al., 2017).

This necessitates a significant transformation in operational business practices and the conceptualisation of value creation within organisations (Froese et al., 2023; Nesterova et al., 2025). Similarly, the concept of degrowth challenges and transforms the education of management and business, which has traditionally relied on growth-based strategies (Bobulescu, 2022; Laasch, 2024). Literature on degrowth or post-growth pedagogy has emerged in recent years, and it appears as a growing theme in the field of education for sustainable development. Although literature is still scarce, there is a need to synthesise the existing research on the topic in order to identify the key ideas behind the degrowth pedagogy. This study addresses the following research question: *What constitutes the fundamental elements of degrowth pedagogy in management and business education, and how are these elements manifested across the micro, meso and macro levels?*

2. Degrowth in management and business

Critiques of perpetual economic growth underpin the fields of growth-critical science, degrowth, and post-growth (Toikka et al., 2026). Degrowth seeks to address the problems inherent in the socio-economic system of capitalism – characterised by a growth-focused and linear economy – as well as the shortcomings of green growth (Levelt et al., 2026). It shares a common foundation with the closely related concepts of sufficiency and regeneration within the framework of strong sustainability, all of which emphasise systemic change (Levelt et al., 2026). While degrowth is a systems-level theory, sector-specific and piecemeal interpretations of degrowth are valuable, and degrowth research does not need to be

comprehensive or consistently oriented towards a unified paradigm, particularly given the uncertainty surrounding the form that a sustainability transition may ultimately take (Toikka et al., 2026).

Literature has discussed the implications of degrowth to businesses and developed criteria to assess whether a company follows a degrowth paradigm (Khmara & Kronenberg, 2018), proposed ideas on what firms should be for a degrowth economy and society to be possible (Nesterova, 2020), identified degrowth-oriented value creation patterns from existing businesses (Froese et al., 2023) and depicted what an ideal degrowth business may look like (Nesterova et al., 2025). Degrowth-oriented business, for example, deviates from profit maximization imperative and overcome economic growth dynamics, for example through real cost pricing, investing in efficiency gains without growth motives and balancing the organisational scale, value non-human life and long-term view, engage consumers for sufficiency, and rely on democratic governance and collaborative value creation (Khmara & Kronenberg, 2018; Nesterova, 2020; Froese et al., 2023; Nesterova et al., 2025). Furthermore, degrowth policy proposals' intended changes in production and consumption consist of socially useful production (i.e. reducing overproduction), democratic, not-for-profit business models, relocalising economic activities, limit advertisement, lifestyles of sufficiency, and reduce waste (Fitzpatrick et al., 2022). It has been acknowledged that perfect degrowth businesses do not exist in the current system (Nesterova et al., 2025).

3. Method

This study is based on an integrative literature review, a method that "reviews, critiques, and synthesizes representative literature on a topic in an integrated way such that new frameworks and perspectives on the topic are generated" (Torraco, 2005, p. 356). The literature on degrowth pedagogy remains relatively fragmented, and established frameworks are largely absent; therefore, an integrative review offers a means of clarifying and structuring this emerging field of research. A systematic search was conducted in Scopus and Web of Science using two search queries. The query "(degrowth OR post-growth) AND (education OR pedagog* OR learning)" was applied to the Title field, and the query "(degrowth OR post-growth) AND ("business education" OR "management education")" was applied to the Abstract, Title, and Keywords fields. The review process was organised using the web-based systematic review management tool Covidence. The search queries yielded 53 articles from Scopus and Web of Science after the removal of duplicates. Following the screening of titles and abstracts, 13 irrelevant sources were excluded. Subsequent full-text screening led to the exclusion of a further 24 studies. Only peer-reviewed journal articles and review papers published in English were included, and no time restrictions were applied. Studies were excluded if they did not focus on degrowth pedagogy or education as their primary subject, or if they addressed degrowth pedagogy only within a specific context rather than in general, or solely within a business and management context. Two additional articles were excluded because they were not accessible. Consequently, a total of 15 articles were included in the review for in-depth analysis. Integrative reviews require conceptual structuring to clarify how the main concepts of the topic come together as a unified idea (Torraco, 2005). This study first provides an overview of the reviewed articles and then organises the elements of degrowth pedagogy in management and business education across three levels – macro, meso and micro – encompassing the societal, institutional and classroom-level manifestations of degrowth pedagogy. The micro-meso-macro framework is employed to capture the multi-level nature of degrowth pedagogy and the educational transformations required for its implementation.

4. Results

4.1. Overview of the reviewed articles

The reviewed articles were published between 2019 and 2026, with the majority appearing within the past three years, suggesting that the field of degrowth education and pedagogy remains relatively nascent and is still emerging. The reviewed articles can be divided into two groups based on the level of analysis on which they focus. Most studies operate at the micro and meso levels, addressing degrowth-oriented learning and teaching practices, learning environments, and the implications of degrowth for course and curriculum design (Kaufmann et al., 2019; Bobulescu, 2022; Kopnina & Bedford, 2024; Kopnina et al., 2024; Laasch, 2024; White, 2024; Kopnina et al., 2025a; 2025b; Liuzzo, 2025; Liuzzo & Tsai, 2025). Some of these studies explicitly argue for "degrowth pedagogy" or "pedagogy for degrowth" and propose frameworks or principles upon which it is based (Kaufmann et al., 2019; Bobulescu, 2022; White, 2024; Liuzzo, 2025; Liuzzo & Tsai, 2025), whereas others position degrowth as part of ecopedagogy and critical pedagogy (Kopnina & Bedford, 2024; Kopnina et al., 2024; Kopnina et al., 2025a; 2025b). Laasch (2024), by contrast, does not explicitly discuss degrowth pedagogy but instead relates degrowth to the radicalisation of management education. He refers to "disobedience pedagogy", which draws on

existing strands of critical degrowth pedagogy but goes a step further by enabling future managers to translate their dissent from growth into forms of civil disobedience.

One-third of the studies adopt a meso- and macro-level perspective, examining degrowth education more broadly at the systemic level of institutions and society (Jones, 2021; Baldacchino & Saeverot, 2024; Selwyn, 2024; Tannock, 2025; Rudolph et al., 2026). These articles call for a fundamental rethinking of education from a degrowth perspective, examining how degrowth values and principles can inform the development of educational practices and the redefinition of educational aims (Jones, 2021; Baldacchino & Saeverot, 2024; Selwyn, 2024; Rudolph, 2026). Tannock (2025, p. 464), however, offers a distinctive perspective by adopting a critical stance towards the notion of "degrowth education", and arguing that it offers "an essential set of questions, critiques, perspectives and proposals that educators need to engage with" but not a single overarching framework for educational reform.

4.2. Macro: Societal level analysis of degrowth pedagogy

Resisting the growth paradigm What is reflected across all the studies is that degrowth pedagogy is inherently oppositional and defines itself through resistance. Degrowth is a resistance to the imperatives of growth and techno-solutionism in education (Rudolph, 2026). It resists the neoliberal straitjacket that constrains thinking in business education (Liuzzo, 2025). Furthermore, radical degrowth, alongside a radicalising disobedience pedagogy, is considered necessary to undermine the dominant paradigm of neoliberal growth and the regime that sustains it (Laasch, 2024).

Critical thinking and questioning Through its critical orientation, it is recognised as grounded in critical pedagogy (Bobulescu, 2022; Liuzzo, 2025) but also seen to contribute to it by questioning the ideology of progress and its technological dimension (Bobulescu, 2022). At its core lies a commitment to challenging, questioning, and resisting dominant assumptions. It seeks not merely reform but the transformation and, ultimately, the dismantling of the growth paradigm, rather than primarily focusing on the transmission of degrowth theory, values, and principles. Many studies characterise it as multi-paradigmatic, in the sense that it aims to offer alternative perspectives beyond the growth-oriented capitalist paradigm (Kaufmann et al., 2019; White, 2024; Liuzzo, 2025; Liuzzo & Tsai, 2025). As Tannock (2025, p. 457) argues its goal should not be "to indoctrinate learners into degrowth theory but [to] engage them in critical reflection on hegemonic discourses of growth that permeate contemporary society". Similarly, Liuzzo (2025, p. 5) states that the value of degrowth "lies in its broad critique rather than adherence to a narrowly defined agenda". Unlearning growthism, progress, and technologically driven paradigms, namely the fundamentally flawed, taken-for-granted assumptions and practices, forms the basis of degrowth pedagogy (Bobulescu, 2022; Laasch, 2024; Rudolph et al., 2026).

Thinking and realising degrowth At the same time, what distinguishes degrowth pedagogy is its explicit degrowth orientation. Its distinctiveness lies in challenging economic growth and in proposing an alternative, fundamentally opposed, and radical model of economy and society. Thus, giving space to degrowth theories has been recognised as an important element of degrowth pedagogy and education (Liuzzo, 2025; Liuzzo & Tsai, 2025; Tannock, 2025). Degrowth theory thus functions as a catalyst for challenging the growth paradigm and identifying alternative pathways. In this way, degrowth pedagogy aims to respond to calls for profound transformation within education, recognising that education in its current form has been unable to prevent or alleviate the ecological crisis.

Conviviality, care and emancipatory capacities Degrowth pedagogy seeks to support a transition towards a world beyond growth, which requires a radical transformation of social imaginaries and broader cultural change leading to new life objectives (White, 2024). It is therefore understood as necessitating a transformative, critical-emancipatory approach (Kauffman et al., 2019), aimed at fostering active citizenship and individual empowerment (Bobulescu, 2022; Kopnina & Bedford, 2024). Liuzzo (2025) refers to a 'childlike' mindset that is emancipatory and capable of disrupting taken-for-granted ways of doing things. Several studies emphasise the values that degrowth may introduce into education, such as conviviality, care, reciprocity, and companionship (Selwyn, 2024; Rudolph et al., 2026). In this sense, degrowth pedagogy is seen to reshape the very aims of education (Rudolph et al., 2026). Selwyn (2024), for instance, critiques the continued excessive application of digital technologies in education, arguing that educational technologies should instead align with degrowth principles – fostering conviviality, autonomy, communing, and care – while remaining understandable, empowering, and controllable by their users. Similarly, Jones (2021) envisions degrowth education as grounded in the principles of simplicity, conviviality, care and ritual destruction of accumulation. Such an approach limits possibilities, rejects competitive individualism, performance metrics and the tendency to accumulate more knowledge. In contrast, Tannock (2025) does not believe that degrowth is a good framework for an education reform arguing that education is a sector that should grow – not degrow.

4.3. Meso: Institutional level analysis of degrowth pedagogy

Ecocentrism and ecoliteracy Institutional-level analyses of degrowth pedagogy at the level of universities or curricula remain largely absent from the existing literature. Kopnina and Bedford (2024), however, argue that curricula guided by the Sustainable Development Goals (SDGs) should be further developed towards a degrowth-informed ecopedagogy – one that is ecocentric, biodiversity-focused, and oriented towards fostering ecoliteracy and interdisciplinary approaches that integrate ecology, business, and the social sciences. Mainstream education for sustainable development has been criticised for reproducing the dominant economic paradigm (Kauffman et al., 2019; Baldacchino & Saeverot, 2024; Rudolph, 2026).

4.4. Micro: Classroom level analysis of degrowth pedagogy

Understanding historical, value-laden and political nature of social systems To support anti-paradigmatic thinking within degrowth pedagogy, the deconstruction of the historical emergence of the growth paradigm is crucial (Laasch, 2024). Recognising its historical, value-laden, and political nature serves to counteract the self-fulfilling inevitability often attributed to the growth paradigm. When framed as a socially constructed paradigm, it restores a sense of agency to students (Liuzzo, 2025). Similarly, Kauffman et al. (2019) emphasise the politicisation of education – that is, opening educational spaces to questions of power and to a plurality of alternative perspectives.

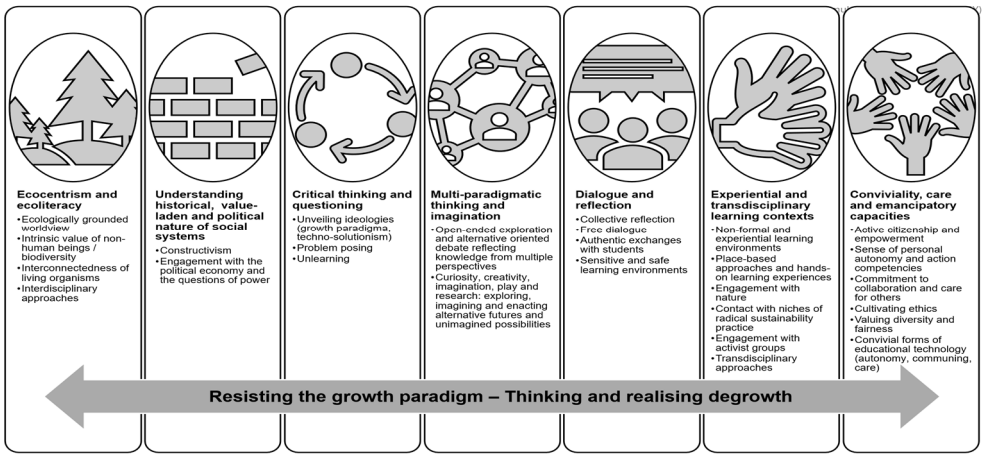
Multi-paradigmatic thinking and imagination Many studies emphasis – related to the critical questioning – the open-ended exploration and the imagining of alternative futures (Bobulescu, 2022; Baldacchino & Saeverot, 2024; White, 2024; Liuzzo, 2025; Liuzzo & Tsai, 2025). Terms, such as rethinking, reimagining and reshaping are frequently employed to characterise degrowth pedagogy. Liuzzo and Tsai (2025) describe degrowth pedagogy as a means of addressing the 'crisis of imagination' in business schools. Similarly, Liuzzo (2025) highlights the importance of plurality, emphasising that knowledge should be critically reflected upon from multiple perspectives. Bobulescu (2022), in turn, advocates for curiosity and research, and stimulating creativity through alternative-oriented debate.

Dialogue and reflection / Experiential and transdisciplinary learning contexts Degrowth pedagogy emphasises open discussions, dialogue and reflection (Kaufffman et al., 2019). Furthermore, Kauffman et al. (2019) and Laasch (2024) highlight role of non-formal settings as learning environments and transdisciplinary experiential learning. Laasch (2024) suggest that teachers could facilitate student engagement with activist groups and invite radical activist to discuss with students to support students in enacting resistance and civil disobedience. Similarly, Kaufmann et al. (2019) encourages to establish direct contact to existing niches of radical sustainability practice. Overall, sensitive and safe learning environments that enable experiential learning are seen crucial (Kaufmann et al., 2019).

5. Discussion and conclusions

Figure 1 illustrates the elements of degrowth pedagogy in management and business education. While macro-level visions concerning the significance and aims of degrowth pedagogy are present across all articles, meso-level analyses remain largely absent, particularly with respect to what degrowth pedagogy entails at the level of universities and curriculums. Overall, degrowth pedagogy remains an emerging field of study, and its relationship to related educational perspectives, such as critical pedagogy, ecopedagogy, and transformative sustainability education, requires further elaboration.

Figure 1. Fundamental elements of degrowth pedagogy.



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CHALLENGES IN ADAPTED PHYSICAL EDUCATION IN MAINSTREAM AND SPECIAL SCHOOLS IN THE BRICS COUNTRIES

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Abstract

Despite policies supporting inclusive education, the practical application of Adapted Physical Education remains inconsistent in the BRICS nations (Brazil, Russia, India, China, and South Africa). This study explored the challenges in implementing Adapted Physical Education in mainstream and special schools across the BRICS countries with the purpose of making recommendations for good practice. Using Bronfenbrenner's Ecological Systems Theory and the Cultural-historical Activity Theory, a qualitative approach was followed within an interpretive paradigm to examine barriers at various systemic levels, including policy implementation gaps, resource constraints, and teacher training deficiencies. The findings indicate that while BRICS countries have legislative frameworks supporting Adapted Physical Education, practical implementation is hindered by inadequate infrastructure, insufficient teacher training, limited curriculum support, and societal perceptions undervaluing Adapted Physical Education. Russia appears to have more structured Adapted Physical Education programmes, whereas Brazil, India, China, and South Africa report greater inconsistencies in policy enforcement. Participants emphasised the need for increased government funding, professional development, and community awareness to enhance Adapted Physical Education accessibility. The study highlights the necessity of bridging the gap between policy and practice, advocating for comprehensive teacher education, resource allocation, and cultural shifts to support Adapted Physical Education. The findings contribute to the discourse on inclusive education and provide recommendations for strengthening Adapted Physical Education implementation in BRICS nations.

Keywords: *Adapted Physical Education, BRICS countries, barriers, inclusive education, special education.*

1. Introduction and background

Every child, including learners with special educational needs (LSEN), has a fundamental right to education according to the Salamanca Declaration (1994), a framework for action in inclusive education compiled at the World Conference on Special Needs Education in Salamanca, Spain in 1994 (UNESCO, 1994). The Salamanca Declaration postulated that mainstream or regular schools should accommodate all learners, regardless of their physical, intellectual, social, emotional, and linguistic conditions (UNESCO, 1994).

Inclusive education, as a component of social inclusion, also forms part of the objectives of the original BRICS (Brazil, Russia, India, China and South Africa) organisation, which formed in 2009 with the primary objective to develop and strengthen their economies through collaboration and cooperation. Endorsing the principles of the Salamanca Declaration, the BRICS countries all have well-designed policies that mandate inclusive education (UNESCO, 2024).

One subject that forms an integral part of inclusive education is Adapted Physical Education (APE), which focuses on the adaptation of Physical Education (PE) to the needs of LSEN. However, according to Burnett (2020a) and Liang, Li, Wu, Hou and Sit (2022), some BRICS countries struggle to implement quality APE. The consequences of LSEN not being exposed to APE, often include sedentary behaviour leading into adulthood, with poor health results. Studies in individual BRICS countries show that challenges faced in the implementation of APE, include PE teachers feeling inadequately trained to work with LSEN (Burnett, 2020b), LSEN not always having access to appropriate learning environments, and LSEN often feeling more socially isolated than normal learners. Against this background, the aim of this study was to explore the challenges experienced in the implementation of APE across all BRICS nations.

2. Theoretical framework

The study was conducted within the framework of the Ecological Systems Theory (EST) of Bronfenbrenner (Bronfenbrenner & Morris, 2007) and the Cultural-Historical Activity Theory (CHAT) (Sannino & Engeström, 2018). The challenges were linked to the EST's five interconnected environmental systems and the proposed social, cultural, and historical process of a child's learning and development, incorporating context, collaboration, and the use of tools in shaping behaviour and learning, according to the CHAT.

3. Methodology

In this study a qualitative approach was followed within an interpretive paradigm. Purposive sampling was employed by selecting and inviting experienced experts in inclusive education, who were familiar with the particular country's APE systems in mainstream and special schools. Open-ended questionnaires, which had previously been peer-reviewed and refined, and individual, semi-structured interviews conducted using the Zoom application, were used to collect data. In total, 11 participants (one from Brazil, two from Russia, one from India, two from China, two from South Africa, and three anonymously) completed the questionnaire, while interviews were conducted with seven other participants (one from Brazil, one from India, two from China and three from South Africa). Thematic inductive data analysis was conducted. For trustworthiness, triangulation, member checking, peer debriefing and an audit trail were employed. All ethical requirements were adhered to and the study was approved by a relevant ethics committee (NWU-0299-22-A2).

4. Findings and discussion

The primary themes that came forth in the data analysis, were: *Disconnect and practical implementation, The perceptions of APE in the community, Resources and curriculum support for APE,* and *Training and qualifications of teachers.*

4.1. Disconnect between policy intention and practical implementation

Participants from Brazil, India, China and South Africa indicated that policies to implement APE in mainstream as well as special schools, are in place in their countries, but that the practical implementation thereof is lacking. For example, one participant from Brazil stated, "The biggest challenges are the practical applicability of the educational guarantees provided for in the legislation, there is still this gap between what is intended and what is implemented" (Questionnaire participant 1, Brazil).

In contrast, a participant acclaimed the provision of APE to learners in Russian mainstream schools, as well as those who cannot be accommodated in ordinary schools, as stated, "OLSEN students participate in physical education and sports in schools in Russia on an equal basis with ordinary children (inclusive classes…" (Questionnaire participant 2, Russia)

In agreement with the findings, several researchers (Parente & Pessoa, 2021) point out that the implementation of inclusive education policy is applied differently in the various states of Brazil. Similarly, discrepancies in India in the implementation of inclusive education policies still exist between the different states in the country. In this regard, Vos and De Beer (2018) asserted that the decentralised governance systems of Brazil, India and South Africa can present challenges regarding the implementation of policies and curricula because state, provincial or city governments can adapt aspects of the implementation thereof according to their own discretion. In South Africa, Muthukrishna and Engelbrecht (2022) contended that the White Paper 6 (South African Department of Education [SADE], 2001) attend more to the placement of LSEN in different types of schools (mainstream, full-service or special schools) than the quality of teaching and learning. In China, equal access to education for LSEN forms part of major educational reforms that have been implemented by the government during the last decade with the aim of enhancing learners' health, although Qiwen, Ruisi and Ali (2024) indicate that APE in regular classrooms still experienced implementation challenges. In contrast, Erdyneeva, Schetinina, Makarov, Sokolova, Rozhnova and Krokhina (2021) and participants from Russia perceived the implementation of APE policies in Russia to be efficient and positive, although APE should be developed further.

4.2. Perceptions of PE and APE in the community

Several participants alluded to the influence of school community members' perceptions of PE, on the presentation of APE in the school. Some participants indicated that school communities often perceive PE as an inferior subject which impacts the implementation of APE, as one participant mentioned,

"Many mainstream schools in India prioritize academic subjects over physical education, leading to a lack of emphasis on developing inclusive PE programs" (Interview participant 4, India).

Even when aware of the value of APE, school communities' negative views of inclusive education in mainstream schools, impeding APE, were noted. Perceptions of Indian communities regarding girls and disabled learners, and gender stereotypes in sport and physical activity in Chinese culture were also mentioned: "Traditionally, boys are more fit to do sports and physical activities, while girls should do housework and light activities, even more so with disabled learners" (Questionnaire participant 3, China).

Studies in all the BRICS countries (Burnett, 2020b and Liang et al., 2022) show that parents and communities often have a perception of PE as being inferior to other subjects, and a waste of time. In a study by Khumalo, Naidoo and Chetty (2022), LSEN felt that there is a need for improved governance in schools and communities with regards to APE, and in a national study on the status of PE in South Africa, Burnett (2020b) concludes that the low status of PE and APE is a result of the complex influences caused by misconceptions of the nature of PE, inadequate leadership roles, socio-political priorities, the non-academic status of the subject and poor resources. According to Kirilina et al. (2017), APE in Russia is underestimated and the holistic approach to life quality is undervalued, leading to the lower status of APE specialists and fewer university students enrolling for APE courses. Research by Qiwen et al. (2024) and Chennapragada (2021) supports the view that communities and parents' lack of knowledge often prevents LSEN from participating in APE or sport.

4.3. Resources and curriculum support for APE

Several participants referred to challenges faced with regard to equipment, facilities, and limited time allocations for APE in mainstream and special schools in the BRICS countries.

One participant from South Africa stated that "there isn't really any resources or support" (Questionnaire participant 6, South Africa). Other South African participants further referred to limited time and a lack of facilities for APE. The Brazilian participants also mentioned that, especially in certain regions of their country, limited resources were available for APE at mainstream schools.

In contrast, participants from Russia and China confirmed that there were sufficient facilities and resources available for the effective implementation of APE: "At the moment, most schools have either created or are creating all the conditions (premises and equipment) in schools for the presentation of APE to OLSEN students" (Questionnaire participant 2, Russia).

According to Dheesha (2017), the majority of Indian schools do not have sufficient facilities, infrastructure and equipment to involve LSEN in PE. Additionally, up to 75% of LSEN live in rural areas in India, with little resources available (Singh, 2021). The challenge of limited time in PE lessons to include LSEN, is also reported in studies in Brazil, Russia, India and South Africa (Burnett, 2020; Chennapragada, 2021; Kirilina et al., 2017). In Brazil, India and South Africa, PE teachers are overwhelmed by large classes, insufficient space, inadequate equipment and learner's attitudes toward PE (Burnett, 2020a; Gale, Bhushan, Eidnani, & Graham, 2022). Other barriers in Brazil include poor infrastructure, lack of assistants and insufficient experience in working with LSEN (Greguol, Malagodi & Carraro, 2018). In China, although studies reported restricted access to PE for LSEN due to facilities and insufficient equipment, recent educational reforms in China seem to have addressed these barriers (Liang et al., 2022).

4.4. Teacher qualifications and training

The findings indicate a lack of PE teachers that are trained and/or qualified to teach APE in Brazil, India, China and South Africa. According to the participants from Brazil, pre-service PE teacher training does not include APE, one saying that "It is a shameful situation. Colleges won't prepare you to receive students with special needs and teachers must pay more to get a post degree and be able to attend those students" (Questionnaire participant 1, Brazil).

The Indian participants pointed out that limited APE teacher training was offered at universities in India due to a lack of support in terms of state policies and available resources. Participants from China also referred to a shortage of trained APE teachers, with one stating that "Various universities in China have Bachelors' Degrees in inclusive PE, but there is a shortage of specialised IPE teachers in the country" (Interview participant 3, China). Another Chinese participant reported outdated professional training in APE, and "…a lack of a unified national standard for APE to serve as a reference" (Questionnaire participant 3, China).

No participant from South Africa knew of any PE teacher training programmes that included APE training. Contrary to the lack of teacher training in the other countries, the Russian participants believed Russian PE teachers are well-trained to present APE efficiently

The experiences of the participants generally concur with findings reported in the literature. Although the Brazilian national guidelines for undergraduate PE training state that PE teachers should be trained to diagnose, plan and teach physical activities to learners with disabilities, Barros, de Faria Coelho and Martins (2023) found that there was still a lack of specialised teacher training in APE in the country. In Russia, teacher training in APE is available in a number of Russian universities and regulated by state standards, while continuing teacher education is mandated (Baranov et al., 2018). However, all Russian schools did not necessarily have teachers who were trained regarding the specific needs of such learners (Baranov et al., 2018).

In India, PE teachers need to take a post-degree certification course to be equipped and qualified to teach LSEN in the PE class. Although Chinese policies and governmental decrees show strong support for the training and enhancement of special education teachers and various universities offer high-level APE teacher training programmes, the study of Liang et al. (2022) showed that the lack of knowledge and training, and attitudes of APE teachers towards LSEN, were major factors impeding APE.

In South Africa, research shows low competence in teaching APE among PE teachers due to no pre-service APE training in PE (Muomezie, 2018), and only one South African university's academic yearbook includes a specific APE course (NWU, 2025).

5. Conclusion

Viewing the findings within the context of Bronfenbrenner's EST and the CHAT frameworks, the complex network of APE challenges within the activity system of APE in the different ecosystems of the BRICS countries, are exposed. Within the framework of the EST, the development of LSEN at the microsystem level is often negatively impacted by the lack of appropriate facilities and equipment and time allocation for PE, which can both be seen as tools within the framework of the CHAT. Untrained or underqualified teachers, and the perceptions of teachers and peers, which are part of the community component according to the CHAT, also impact the development of LSEN in the microsystem. Within the mesosystem, perceptions of the value of APE of school communities including school managers and parents (also part of the community component of the CHAT) impede the participation and development of LSEN (in Brazil, India and South Africa). The shortage of APE-specialised teachers due to inadequate teacher training programmes reflects flaws within the exosystems of Brazil, India and South Africa as well as in the community component of the CHAT.

Overall, most of the reported challenges relate to discrepancies in the implementation of national policies at district and school level, as reported in Brazil, India and South Africa, highlighting the negative effects of this relationship between the macro- and mesosystems of these countries. The implementation of APE policies, as the "rules and norms" component of the CHAT, should thus be improved to enhance the learning and development of LSEN in APE. Despite its limitations (the relatively small study population), the study makes a valuable contribution to the field of APE, education and health pertaining to BRICS.

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INTERCULTURAL AND DIASPORIC EDUCATION IN RURAL SCHOOLS: NARRATIVES AND DRAWINGS ON MIGRATION AND BELONGING

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Abstract

This study examines the integration of diasporic and intercultural education in rural primary schools in Spain, focusing on how students represent migration and cultural diversity through narratives, drawings, and audiovisual production. Using Grounded Theory and a participatory ethnographic approach, it involved 56 sixth-grade students from two schools in Aragón, together with teachers, migrant families, and the school community (Hernández Carrera, 2014; Balcázar, 2003; Gholami, 2025). The study combined artistic production and pedagogical intervention. Students created narratives and drawings on migration and interculturality, analyzed through content analysis and used to develop an animated short film. Semi-structured interviews and classroom observations complemented these materials, exploring integration processes and belonging. Findings show that diasporic education fosters empathy, participation, and intercultural learning while transfor Ming classroom dynamics and curricular practices (Gholami, 2023; Nieto, 2017; Banks, 2013). Students' drawings and the audiovisual project enabled emotional expression, identity construction, and reflection on migration (Fernández–Labayen et al., 2022; Macleroy & Shamsad, 2020). The study also identifies challenges such as linguistic and cultural barriers, peer grouping by cultural affinity, and limited teacher training. Although policy frameworks promote inclusion, implementation remains uneven, highlighting the need for stronger curricular and pedagogical integration of interculturality (Gholami & Costantini, 2025; Vidal Prado, 2023).

Keywords: *Intercultural education, diasporic education, migration, drawings, belonging.*

1. Introduction

In developed countries, school systems face challenges in responding to the needs of children and young people from ethnic, cultural, and religious minorities, resulting in persistent patterns of educational inequality. Spain is no exception: both urban and rural schools have experienced a significant increase in cultural and linguistic diversity, particularly due to the arrival of migrant families from Morocco, Latin America, and Eastern Europe. This study explores how intercultural education can be enhanced through artistic and narrative expression in primary schools located in low-population-density areas, connecting local findings with international debates on diasporic education and creative pedagogy to address racism, social exclusion, and marginalization of minority students (Gholami & Costantini, 2025; Banks, 2013).

Diasporic education recognizes the transnational identities and cultural ties of minorities as educational resources, fostering more diverse, creative, and inclusive classrooms (Gholami, 2025). Traditional materials—such as posters or activities focused on food and clothing—are limited and often represent minority students in a static or "exotic" manner (Gholami & Costantini, 2025). Moreover, previous research primarily focuses on teacher-led interventions, without exploring the perceptions and narratives of the children themselves.

This study centers on how students perceive and represent migration through interviews, written narratives, and drawings, generating transmedia narratives that combine multiple expressive languages (Scolari, 2013). Graphic productions play a key role as a means of expression to convey emotions, relationships, and experiences that complement verbal discourse and enrich the understanding of diversity and intercultural coexistence in the classroom.

The research is guided by three questions:

1. How does the concept of diasporic education help interpret these narratives and inform more inclusive teaching practices?

2. How do primary school students in low-population-density areas of Spain perceive and represent migration through written stories and drawings?

3. How can children's artistic productions be incorporated into pedagogical strategies for intercultural education?

Through these questions, the article examines students' narratives and artistic productions and discusses how the findings contribute to the development of inclusive pedagogical strategies inspired by diasporic education, establishing connections between theory and educational practice in diverse school contexts.

2. Literature review

Migration has historically shaped societies through cultural diversity and changing forms of social cohesion (Matos & Permisian, 2016). The concept of diaspora has evolved from the dispersion of people maintaining homeland ties (Safran, 1991; Sheffer, 2013) to include transnationality, hybridity, and multiple belongings that influence host societies (Hall, 1990; Clifford, 1994; Gilroy, 1993; Gholami, 2017, 2025).

In Europe, migration patterns shifted after the postwar period and the fall of communist regimes (Faa et al., 2014). Countries such as Chile, Argentina, and Spain have become immigration contexts (Martínez Rojas et al., 2021; Jiménez Bautista, 2006). In Spain, foreigners represented 11.6% of the population in 2022, mainly from Morocco and Romania (INE, 2023; OPI, 2024; Statista, 2023), while Catalonia has seen growing numbers of immigrant-origin students (Badía Martín & Devant Cerezo, 2024). Migration has also helped revitalize depopulated rural areas (Gracia Bernal et al., 2022; Pinyol-Jiménez et al., 2020).

Migratory and diasporic experiences influence identity construction and classroom coexistence, making intercultural education central to inclusion and diversity policies (Gholami, 2025; UNESCO, 2006; Council of Europe, 2010; United Nations, 2015; Ley Orgánica 3/2020, 2020; Orden ECD/794/2022, 2022). Literature on intercultural and diasporic education highlights its role in supporting migrant student integration and coexistence in diverse societies.

2.1. Intercultural education

Multicultural and intercultural education differ in focus. Multicultural education aims to reduce inequalities and recognize cultural diversity in schools (Banks, 2013; Nieto, 2017), whereas intercultural education promotes dialogue, inclusion, intercultural competence, and social justice through interaction among cultural groups (Martínez Rojas et al., 2021; Deardorff, 2006; Chibici-Revneanu, 2020; Faa et al., 2014). However, it is often reduced to superficial recognition of diversity without addressing structural inequalities (Coulby, 2006; Conti, 2025; Gholami & Costantini, 2025). Diasporic education complements this approach by incorporating transnational identities and minority experiences.

2.2. Diasporic education

Diasporic education includes practices developed with diasporic communities that challenge dominant curricula and educational models (Gholami, 2017, 2025). It seeks to support the integration of diasporic children by recognizing their multiple identities and transnational connections (Gholami, 2023, 2025). This approach also examines how social and political forces shape education, questioning nationalist perspectives and fixed ethnic or religious identities (Coulby, 2006; Nieto, 2017; Gholami, 2017, 2023).

Creative expression through narratives, art, and audiovisual media is central to diasporic education, as it validates migrant identities, challenges hegemonic discourses, and promotes empathy and intercultural understanding (Nieto, 2017; Fernández–Labayen et al., 2022; Gholami, 2023, 2025).

2.3. Creative and narrative expression in intercultural and diasporic education

Narrative and artistic expression are key tools in intercultural and diasporic education, as they give visibility to students' experiences, promote empathy, and challenge dominant discourses (Nieto, 2017; D'Amore & Díaz, 2020). Personal narratives support identity construction, social justice, and the integration of migrant students within host communities.

Research highlights the educational value of storytelling and creative practices. Gholami (2025) showed how theater workshops based on migration stories fostered empathy and historical understanding, while Chibici-Revneanu (2020) used expressive writing to validate diasporic identities and question hegemonic narratives. Audiovisual projects also enable students to share life stories and cultural memories, strengthening intercultural learning (Fernández–Labayen et al., 2022). Drawings and other artistic productions complement oral and written narratives by expressing emotions and migration experiences through visual language (Gholami, 2023; Fernández–Labayen et al., 2022).

Similarly, activities involving letters, songs, dances, and migrant students' life experiences promote teacher awareness, empathetic inclusion, and a stronger sense of belonging and inclusive citizenship (Parejo-Llanos et al., 2020; Badía Martín & Devant Cerezo, 2024; Gholami, 2017, 2023).

2.4. Participatory and visual arts in intercultural education

Artistic and audiovisual practices are important tools for intercultural learning, enabling students to explore identity, negotiate hybrid belongings, and connect their cultures of origin with their everyday contexts (Gholami, 2017; Clifford, 1994; Gilroy, 1993). Audiovisual workshops and projects such as Critical Connections encourage migrant students to represent their migration experiences through theater, media production, and storytelling, promoting intercultural understanding and validating their cultural backgrounds (Fernández–Labayen et al., 2022; Macleroy & Shamsad, 2020).

Artistic techniques such as photography, collage, animation, and drawing foster critical reflection on migration and diversity while challenging traditional perspectives (Serber, 2021; Oliver-Barceló & Ferrer-Ribot, 2022). In particular, drawings allow students to visually communicate emotions and diasporic identities, complementing oral and written narratives and strengthening empathy and intercultural understanding (Fernández–Labayen et al., 2022; Gholami, 2017). Audiovisual works such as Pequeñas voces (Carrillo, 2010), Persepolis (Satrapi & Paronnaud, 2007), and Flee (Rasmussen, 2021) further serve as educational references for reflecting on migration, conflict, and cultural diversity.

3. Methodology

3.1. Study design

This study used a qualitative ethnographic and participatory design to analyze how children represent migration and interculturality through narratives and drawings. Framed within Grounded Theory, it developed findings from empirical data without prior hypotheses (Hernández Carrera, 2014). A case study and Participatory Action Research approach were applied, following principles of diasporic education (Gholami, 2025; Balcázar, 2003). The sample included 50 students aged 11–12 from two rural schools in Aragón with culturally diverse populations. The study was structured around two dimensions:

- Artistic material production: Students created written narratives and drawings about migration and interculturality, analyzed through content analysis to identify explicit and latent meanings (Krippendorff, 1980; López-Aranguren, 1984). These materials were later used to produce an animated short film narrated by the students.

- Pedagogical intervention: Semi-structured interviews with teachers, migrant families, and school community members, together with classroom observations, were conducted to examine intercultural interactions and integration processes (Hernández Carrera, 2014; Balcázar, 2003).

Data collection combined narratives, drawings, interviews, and participant observation.

3.2. Research process

The research was carried out in eight phases, focusing on the active participation of students, teachers, and families, and on the creation of visual materials:

1. Coordination with schools: Meetings were held with school principals and teachers to present the project and recruit volunteer staff, receiving their commitment to active participation.

2. Communication with families: An informative letter explaining the objectives and requesting consent was sent. In Teruel, all families agreed to participate, while in Caspe some did not authorize their children's participation.

3. Work with students: A total of 56 sixth-grade students participated (20 in Teruel and 36 in Caspe). During reflection sessions on migration and interculturality, students expressed their experiences through written narratives and drawings, which were later explored in individual interviews.

4. Interviews with the school community: Semi-structured interviews were conducted with four teachers and members of the school community of migrant origin to understand integration and intercultural dynamics.

5. Systematic data collection: Narratives, drawings, and interviews were organized and categorized for qualitative analysis.

6. Data processing: The collected materials were analyzed to structure conclusions and prepare the audiovisual production phase.

7. Short film production: Students' illustrations and narratives served as the basis for the animation and production of a short film by Fine Arts students in Teruel, creatively capturing children's perspectives on migration and intercultural coexistence.

8. Community feedback: The short film was presented to participants and families, returning results and sharing study conclusions, strengthening participation and community learning.

The data were analyzed using thematic coding and content analysis, identifying patterns in how students and teachers conceptualize migration and cultural diversity. The short film was used as an educational resource to promote intercultural education in the region, incorporating teachers' suggestions (Gholami, 2023, 2025).

4. Results

The application of diasporic education was analyzed from two main dimensions (Gholami, 2025):

- Diasporisation of the educational space: Migrant students' presence influenced classroom dynamics and curriculum, integrating their cultural perspectives. Their narratives and drawings made visible emotional and symbolic dimensions that enrich intercultural learning.
- Identity and belonging: Participation through drawings and written/oral narratives supported the construction of belonging. Visual productions allowed students to express emotions, relationships, and migration experiences, complementing verbal accounts.

In Caspe and Teruel, migrant students reshaped classroom interactions, generating new narratives that challenge traditional structures and reveal segregation dynamics (Huarte González et al., 2022; Goenechea, 2016). Their experiences of discrimination and adaptation were expressed through interviews, writing, and drawings, where visual elements (colors, shapes, spatial organization) conveyed emotions and social relations. These productions deepen understanding of intercultural coexistence.

Educational adaptations included curricular adjustments and inclusive practices (e.g., non-denominational rituals or student language mediation), though these depend largely on individual schools due to the lack of explicit curricular inclusion of migration (Orden ECD/866/2024, 2024; Vidal Prado, 2023).

Regarding belonging, students reflected emotional processes of adaptation, including loneliness, language barriers, and nostalgia, alongside strategies such as language learning and participation in shared activities (Banks, 2013; Gholami, 2025). While many report a strong sense of school belonging (Martin et al., 2023), grouping by cultural origin persists in some contexts (Labrador Fernández & Blanco Puga, 2007; Pinyol-Jiménez et al., 2020).

Overall, integrating artistic production enhances empathy, participation, and intercultural understanding. Drawings function as a key visual language that reveals both explicit and latent meanings, allowing deeper insight into how children perceive migration, diversity, and their place in the school context.

5. Discussion and conclusions

The study highlights the impact of artistic narration and diasporic education on the teaching of migration and cultural diversity. Students' narratives and drawings reveal understandings of migration linked to uprooting, family, and belonging, while also showing how schools support integration despite persistent linguistic and cultural barriers affecting peer group formation (Nieto, 2017; Banks, 2013).

The short film based on students' productions proved effective in fostering motivation, reflection, and intercultural empathy, confirming the value of audiovisual tools in intercultural learning (Fernández–Labayen et al., 2022; Macleroy & Shamsad, 2020). This process enabled active student participation in learning construction. Narratives also reflect Brah's (1996) "homing desire," combining family attachment with school belonging and multiple identities (Gholami, 2023, 2025).

Tensions persist between cultural clustering among students and school efforts toward integration. Teacher-led initiatives (language support, inclusive rituals, tutoring) reflect intercultural competence (Deardorff, 2006; Theeuwes et al., 2025; Hagenaars et al., 2025), though their implementation depends on context and training. Although similar practices exist in Ibero-American contexts (Fernández–Labayen et al., 2022; Oliver-Barceló & Ferrer-Ribot, 2022; Serber, 2021; Torrelles Montanuy et al., 2022), transnational dimensions of minority communities remain underdeveloped (Coulby, 2006; Gholami, 2023). Combining audiovisual production with interviews represents a methodological advance aligned with transformative intercultural education (Conti, 2025).

However, these practices remain limited without structural change. Intercultural policies are often disconnected from school realities, and curricular rigidity and segregation persist in Spain (Gholami & Costantini, 2025; Coulby, 2006; Fernández Peña & Filigrana García, 2019; Vidal Prado, 2023). Despite existing frameworks (LO 3/2020; Orden ECD/794/2022; regional plans), implementation is fragmented and uneven (Gobierno de Aragón, 2022; Comarca Bajo Aragón-Caspe, 2023–2026).

Overall, combining narratives, drawings, and audiovisual production enables a participatory and empathetic approach to learning, but its transformative potential depends on deeper curricular and policy integration.

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LEARNING MATHEMATICS THROUGH INTEGRATION OF MUSIC ACTIVITIES

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Abstract

This study examines the impact of music on mathematics learning for first grade students, focusing on the role that rhythm, melody, and musical activities play in the acquisition of basic mathematical concepts. In primary education, especially in first grade, students face challenges in understanding numbers, simple operations, and spatial-temporal relationships. Integrating music into the learning process represents an innovative approach that promotes motivation, concentration, and active involvement of students. The study is based on contemporary pedagogical literature and concrete practices implemented in the classroom, where songs, rhythmic games, and exercises with musical elements are used to reinforce concepts such as counting, comparing numbers, addition, and subtraction. The results show that the use of music has a positive impact on improving memory, developing logical skills, and creating a more engaging and collaborative learning environment. Participants of the study are first grade teacher and professor of music education (authors of the study) 60first grade students of elementary public school of Gjakova, Kosovo. The methodology of the study is the participatory action research. The intervention program is based music activities. For the study were used qualitative and quantitative data collection techniques: interviews with teachers, and tests and observation. The results from this study will explain that the use of music activities can improve student's skills learning mathematics. In conclusion, the paper emphasizes that music is not just an entertainment tool, but an effective pedagogical strategy that can increase the quality of learning in mathematics in the primary cycle, contributing to the comprehensive development of children.

Keywords: *Musical activities, interdisciplinary, mathematic learning, motivation.*

1. Introduction

Mathematics in the early grades constitutes a fundamental basis for students' further academic development. However, classroom practice shows that many first-grade students face difficulties in acquiring basic mathematical concepts such as counting, comparing numbers, and performing basic operations like addition and subtraction. According to Piaget (1952), children at this age are in the concrete operational stage, where learning is more effective when it is supported by concrete experiences and hands-on activities. This suggests that traditional abstract teaching methods may not always be sufficient for developing mathematical understanding.

In response to these challenges, it is important to use innovative teaching approaches that are appropriate for students' age. One such approach is the integration of musical activities into teaching. According to Gardner (1983), musical intelligence is one of the key forms of intelligence and can be used to support learning in other areas, including mathematics. Music, through songs and rhythmic games, helps develop memory, rhythm, and structure—elements that are closely related to mathematical concepts.

The use of musical activities such as songs and rhythmic games creates a lively and interactive learning environment, increasing student engagement and facilitating the acquisition of abstract concepts. As emphasized by Kemmisand McTaggart (2005), participatory approaches in teaching—based on action and reflection—help improve teaching practices and actively involve students in the learning process.

Studies in the field of education show that music and mathematics are closely interconnected through shared structures such as rhythm, pattern, and temporal organization. According to Collins (2013), musical activities activate areas of the brain that are also involved in numerical processing, positively influencing children's cognitive development.

One of the key aspects of this connection is rhythm. Blythe (2009) emphasizes that rhythmic processing supports the development of basic skills such as sequencing and counting, which are essential for early mathematics. In this context, children who engage in rhythmic activities (rhythm, musical counting, clapping and the use of body percussion(hand and feet)develop a stronger understanding of order and quantity.

Catterall, (2009) argues that participation in the arts, including music, is associated with improved academic performance, particularly in mathematics. He highlights that musical activities help students understand patterns and structures, which form the foundation for operations such as addition and subtraction. Musical elements such as rhythm and melody incorporate mathematical concepts like one-to-one correspondence and patterning, making them effective tools for teaching counting and number comparison in early grades.

Furthermore, Hallam (2010) points out that music has a positive impact on working memory and concentration, which are key factors in learning mathematics. Through songs and rhythmic activities, students reinforce their ability to retain and manipulate numerical information.

Another important contribution comes from Mills (2007), who argues that integrating music into teaching increases student motivation and engagement, creating more favorable conditions for acquiring mathematical concepts such as addition and subtraction.

This study aims to analyze the impact of using musical activities on improving first-grade students' mathematical skills, particularly in counting, comparing numbers, addition, and subtraction. By incorporating songs and rhythmic games into mathematics instruction, the study seeks to increase student motivation, deepen conceptual understanding, and contribute to the development of more effective and inclusive teaching practices. Through this approach, it is expected to increase students' motivation and enhance their mathematical understanding, contributing to the development of more effective and inclusive teaching methods.

2. Method

For this study is used participatory action research method, which emphasizes collaboration, reflection, and continuous improvement throughout the research process (Kemmis & McTaggart, 2005). The role of authors of the study was as active contributors in the research process, helping to identify problems, collect data, implement intervention program and interpret findings. McIntyre (2008) notes that PAR integrates reflection and action, allowing participants to investigate their own realities and implement meaningful change.

The intervention program is based music activities: songs, rhythmic games, and exercises with musical elements. For the study were used qualitative and quantitative data collection techniques: interviews with teachers, pre and post-test with mathematical tasks and observation.

The participants were 60 first-grade students of elementary public school of Gjakova, Kosovo, who were actively involved in music-based learning activities designed to enhance engagement and participation.

2.1. Procedure

The study includes action research phases: planning, action, observation and reflection. McNiff, (2013), views action research as a cyclical process of planning, acting, observing, and reflecting, aimed at improving practice and understanding.

2.1.1. Planning. In the initial phase, the teacher-researcher identified challenges in students' understanding of early mathematics concepts such as counting, comparing numbers, addition, and subtraction. For this phase is used pre-test with mathematical tasks to explore student's knowledge about mathematics. Through classroom observations, students' interests in songs and movement activities were explored. Based on this, an intervention plan was developed that integrated music activities—such as counting songs, rhythm-based number games, and movement exercises—to reinforce mathematical concepts.

2.1.2. Action. The intervention was implemented during regular classroom lessons. Students participated in structured music activities that combined math learning with rhythm and movement. For example, counting songs were used to practice number sequences, while rhythmic clapping and stepping games were used to demonstrate addition and subtraction (e.g., adding beats or taking beats away). These activities aimed to make abstract mathematical concepts more concrete and engaging.

2.1.3. Observation. During the implementation, the teacher-researcher observed students' participation, understanding, and ability to apply mathematical concepts during the activities. Data were collected through, post-test and observation of students' responses to tasks involving counting, comparing numbers, addition, and subtraction.

2.1.4. Reflection. After each session, the teacher-researcher reflected on the effectiveness of the activities in improving students' mathematical understanding. Students were also encouraged to share their experiences and indicate which activities helped them learn best. This feedback supported ongoing evaluation of the intervention.

2.2. Revision and re-implementation

Based on the reflections, the activities were modified to better support students' learning needs. More effective music-based strategies were expanded, while less effective ones were adapted. The revised intervention was then re-implemented, continuing the PAR cycle of planning, action, observation, and reflection (McNiff, 2013).

The music activities are implemented during 3 months and the two first grade teachers and authors worked with students in their classrooms during this time. Researchers collaborated with teacher for changing their student's skills in mathematics: counting, comparing numbers, addition and subtraction and developing their teaching practices.

2.3. Instruments for data collection

Data collection instruments were tests (pretest and posttest), observation and interviews with teachers. Pretest was implemented before the action plan and posttest after the action plan in order to evaluate the impact of music activities for student's skills in mathematics, and interviews with teachers were conducted in the planning phase to identify student's difficulties in mathematics. Observation was conducted during the planning and action phases: in the planning to identify student's difficulties in mathematics, during the action to identify action process.

2.4. Sample

Participants of the study were 60 first grade students, 28 students from class I-1 and 32 students from class I-2 (age 6-7 years old), IVA (M=6.62; SD= 0.48) and IV B (M=6.56, SD= 0.50) and their two classroom teachers from the "Mustafa Bakija" primary school, from Gjakova, Kosovo.

3. Results

Based on contemporary literature (Collins, 2013; Hallam, 2010; Catterall, 2009), musical activities such as songs and rhythmic games represent an effective tool for developing basic mathematical skills in first-grade students, as they integrate rhythmic and numerical structures, facilitating the learning of counting, comparison, addition, and subtraction."

Results showed that the student's achievements in mathematics increased after implementing of action plan. That showed student results in post-test.

The t-test was utilized in order to compare the results of the pre-test and the post-test. There was a significant difference from pretests to posttests in the scores of pretests for class I1 (M= 3.50, SD=.839 and posttest (M=4.11, SD=.956), t (27) = -6.450, p=.000 in the class II2 (M= 3.53, SD=.983 and posttest M=4.03, SD=1.031), t (31) = -5.568, p=.000 respectively).

4. Discussion and conclusions

The purpose of this study was to analyze the impact of musical activities, such as songs and rhythmic games, on the development of basic mathematical skills in first-grade students, focusing on counting, number comparison, and basic operations of addition and subtraction.

The action plan with music activities has impact on student's skills for mathematic: numbering, comparing numbers, addition and subtraction. The findings of this study are in line with earlier studies Hallam (2010) and Catterall (2009) emphasize that participation in music and the arts has a positive effect on academic achievement, particularly in mathematics, by improving students' ability to understand patterns, structures, and numerical relationships. Overall, the findings of this study indicate that the integration of music in teaching mathematics in first grade:

- enhances understanding of basic numerical concepts,
- supports the development of counting and comparison skills,

- facilitates learning of addition and subtraction through concrete experiences,
- increases students' motivation and engagement in the learning process.

In conclusion, musical activities represent an effective pedagogical tool for supporting early mathematics learning and should be more widely integrated into classroom teaching practices.

The results from the study confirmed that students improve their skills in mathematics when through music activities such as; songs, music games and rhythm. The rhythm helped the students for numbering, songs for addition, subtraction and comparing numbers, music games for comparing numbers, addition and subtraction.

From this, it can be concluded that teachers should use music activities in mathematics lessons to help students to understand better mathematics concepts and operations, especially in early grades. They should prepare lessons based on learning styles and multiple intelligence

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PRE-SERVICE TEACHERS' PERCEPTIONS AND EXPERIENCES OF USING SMARTBOARDS TO PROMOTE ACTIVE LEARNING DURING TEACHING PRACTICE

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Abstract

This study explored pre-service teachers' perceptions and experiences of using smartboards to promote active learning in South African classrooms during teaching practice. Grounded in Mayer's Cognitive Theory of Multimedia Learning (CTML), the research employed a qualitative design, and semi-structured interviews were administered to five final/fourth-year PSTs at a South African university, who had completed 20 weeks teaching practice over the four years of B.Ed. programme. Findings were analysed using thematic analysis. Findings revealed that participants held positive perceptions of smartboards' potential to foster engagement, collaboration, and differentiated instruction. However, most participants reported feeling inadequately prepared to use smartboards effectively in their teaching practice. Limited training, insufficient hands-on experience during their teacher education programme, and inadequate mentorship during teaching practice were identified as key factors contributing to this lack of preparedness. In addition, participants highlighted several contextual challenges that constrained effective implementation, including technical difficulties, limited access to functioning equipment, lack of technical support, and time constraints within lessons. The study recommends enhancing teacher training curricula to include pedagogically focused, hands-on smartboard teaching and stronger school-university collaboration. This will better equip future teachers to implement smartboard-supported teaching and learning strategies confidently and effectively.

Keywords: *Smartboards, pre-service teachers, active learning, teaching practice, multimedia learning.*

1. Introduction

Education systems worldwide are undergoing significant transformation in response to rapid technological advancement, changing labour market demands, and the evolving characteristics of contemporary learners. These shifts are often associated with the Fourth Industrial Revolution (4IR), which is characterised by digitalisation, automation, artificial intelligence, and increased reliance on technological competencies (Schwab, 2018). As a result, schools are increasingly expected to prepare learners with skills such as critical thinking, collaboration, communication, creativity, and digital literacy. Within this context, teaching approaches that rely solely on traditional teacher-centred methods are increasingly viewed as insufficient for preparing learners for participation in knowledge-based societies (Matemera, 2020). According to De Silva et al. (2016) contemporary learners are described as digital natives because they have grown up interacting with digital devices such as smartphones, tablets, and computers, and therefore often demonstrate familiarity with technology-mediated environments. These learners generally expect more interactive, visual, and participatory learning experiences than previous generations (ibid). Consequently, education systems have increasingly adopted Information and Communication Technologies (ICTs) to align classroom practices with learners' needs and expectations. In South Africa, this commitment is reflected in policy frameworks such as White Paper 7 on e-Education and the Curriculum and Assessment Policy Statement (CAPS), both of which encourage the meaningful integration of ICTs into teaching and learning (Department of Education [DoE],2004; Department of Basic Education [DBE], 2011). Such policy directions recognise that technology can enhance teaching and learning and enable learners to develop competencies required in the 21st century.

Among the technologies introduced into schools are smartboards, also widely known as interactive whiteboards. A smartboard is a large touch-sensitive digital display connected to a computer and projector, allowing users to control applications directly on the board using touch or a stylus (Alshaikhi, 2017). Unlike conventional chalkboards or whiteboards, smartboards integrate multimedia functions such as videos, simulations, animations, internet access, writing tools, and interactive tasks into one platform (Alfaki, 2014). These affordances make them particularly valuable in supporting visualisation, learner participation, and multimodal teaching and learning. Researchers have shown that smartboards can make lessons more engaging, especially when teaching abstract or complex concepts, by presenting content dynamically and interactively (Mihai, 2020; Mkhwebane et al., 2025). The pedagogical value of smartboards is strongly linked to the concept of active learning. Active learning refers to instructional approaches in which learners participate meaningfully in the learning process through discussion, problem-solving, collaboration, inquiry, reflection, and interaction with learning (Bean & Melzer, 2021). Bakadam et al., 2012 and Bozzo et al., 2015 asserted that smartboards can support active learning by enabling learners to manipulate digital objects, participate in quizzes, analyse diagrams, solve problems collaboratively, and engage with multimedia content in real time. Through these functions, smartboards can shift classroom practice from passive transmission of knowledge to more learner-centred pedagogies as both the teacher and learners co-construct knowledge through the smartboard.

In South Africa, several provincial departments introduced smartboards into public schools as part of broader digitalisation agendas. For example, the Gauteng Department of Education (GDE) invested in tablets, laptops, and smartboards to modernise classrooms and reduce historical inequalities in access to educational resources (Matemera, 2020). Such initiatives suggest growing opportunities for teachers and learners to engage with digital teaching tools. However, the meaningful integration of smartboards depends not only on infrastructure, but also on teachers' competence, confidence, and pedagogical readiness to use them effectively. This concern is particularly important in the preparation of pre-service teachers (PSTs). Mavuru and Pila (2021) highlighted that during initial teacher education programme, PSTs are expected to develop the knowledge, skills, and dispositions required for effective classroom practice. One of the most important components of this preparation is teaching practice. Mokoena (2017) defined teaching practice as the supervised period during which PSTs are placed in schools to teach real learners, apply theory to practice, and develop professional competence in authentic classroom contexts. It is widely regarded as a critical bridge between university coursework or theoretical knowledge and the realities of school teaching.

Despite the increasing availability of smartboards in schools, international and South African studies indicate that many PSTs feel underprepared to integrate digital technologies effectively during teaching and learning (Alshaiki, 2014; Mavuru & Pila, 2021; Mihai, 2020). Common challenges include inadequate training at university, limited opportunities for hands-on practice during microteaching sessions, lack of access to functioning smartboards during school placements, and insufficient mentorship from teachers who may themselves lack confidence or expertise in using the technology (Mavuru & Pila, 2021; Mihai, 2020). In some cases, PSTs are placed in schools where smartboards exist but are underutilised, poorly maintained, or inaccessible (Mihai, 2020). Additional barriers include technical faults, poor internet connectivity, malfunctioning equipment, load shedding, time limitations during lessons, and inadequate technical support from schools or departments (Mkhwebane & Mbanze, 2026; Tefo, 2020).

The persistence of these challenges presents a significant concern for initial teacher education in South Africa. Although national policies and provincial investments continue to promote digital teaching, many PSTs may complete their training without the competence and confidence to integrate smartboards meaningfully in classroom practice (Mihai, 2020). This reflects a disconnect between policy intentions, available infrastructure, and teacher preparedness. As noted by Mavuru and Pila (2021), insufficient preparation during teacher education limits the capacity of future teachers to use technology for learner engagement and active learning. In turn, this may reinforce traditional teacher-centred pedagogies that are increasingly misaligned with the needs of contemporary learners and the demands of the 4IR (Mihai, 2020). It is therefore necessary to examine how PSTs perceive and experience the use of smartboards during teaching practice.

2. Theoretical frameworks

This study was guided by Mayer's Cognitive Theory of Multimedia Learning (CTML), which explains that learners understand more effectively when information is presented through both verbal and visual forms (Mayer, 1997) According to Mayer (2024) CTML is grounded in three principles: dual channels, where learners process visual and verbal information separately; limited capacity, where each channel can handle only a small amount of information at one time; and active processing, where learners construct meaning by selecting, organising, and integrating information with prior knowledge. CTML aligns with the use of smartboards because these tools combine text, images, audio, video, diagrams, and

interactive features in one platform (Mkhwebane & Mbanze, 2026). Furthermore, Mkhwebane et al., (2025) posited that such multimodal presentation can enhance attention, comprehension, and engagement, particularly when teaching complex concepts. CTML therefore provided a useful lens for examining pre-service teachers' perceptions and experiences of using smartboards to promote active learning during teaching practice.

3. Research methodology

This study adopted a qualitative phenomenological case study design (Creswell & Creswell, 2018) to explore PSTs' perceptions and lived experiences of using smartboards to promote active learning during teaching practice in South African classrooms. The design enabled the researchers to capturing participants' meanings, reflections, and challenges regarding smartboard use during teaching practice.

Through purposive sampling (Cohen et al., 2017), five final/fourth-year Bachelor of Education (B.Ed.) PSTs were selected from a South African university. Participants were selected because they had completed a cumulative 20 weeks of teaching practice across the four years of the B.Ed. programme and had exposure to smartboards during school placement. Their recent and direct experiences positioned them to provide rich insights into the realities of smartboard integration in classrooms.

Data were collected through semi-structured individual interviews conducted online via Microsoft Teams at times convenient and mutually agreed upon by the researchers and participants. With participants' consent, all interviews were audio-recorded for accuracy and lasted between 30 and 45 minutes. The interview schedule focused on participants' perceptions of smartboards for promoting active learning, their preparedness to smartboards, the support received during teaching practice, and challenges encountered in schools.

Data were analysed thematically using Braun and Clarke's (2006) six-step framework: familiarisation with the data, generation of initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the report. Thematic analysis enabled the identification of recurring patterns related to preparedness, perceptions, opportunities, and barriers to effective smartboard use during teaching practice.

Trustworthiness was ensured through credibility, dependability, confirmability, and transferability. Ethical principles were strictly observed throughout the study. Participation was voluntary, informed consent was obtained from all participants prior to data collection, and anonymity was maintained using pseudonyms to protect identities and confidentiality. An ethical clearance certificate (Sem 1-2025-043) was sought and obtained from the Faculty of Education Research Ethics Committee before commencing with data collection.

4. Research findings

The study found that pre-service teachers perceive smartboards as potent tools that can significantly enhance active learning by increasing student engagement, fostering collaboration, and supporting. Lerato expressed that "smartboards allow me to use pictures and videos so learners can visualize landforms and interact with content," illustrating how multimodal representation supports learners in making sense of abstract geographical concepts. This resonates with CTML, particularly the dual-channel and active processing principles, which argue that learners construct meaning more effectively when visual and verbal information are integrated and actively processed (Mayer, 2024).

Similarly, Ratanang noted that "videos and pictures help learners who dislike writing," underlining the role of visual and multimodal resources in accommodating diverse learner preferences. This reflects broader shifts in education systems that recognise contemporary learners as digital natives who prefer interactive, visual, and technology-mediated learning environments (De Silva et al., 2016). Ratanang's observation suggests that smartboards can support inclusive pedagogical approaches by providing multiple entry points to learning, particularly for learners who struggle with traditional text-heavy instruction.

Siboniso shared that "gamification through tools like Kahoot on IWBs makes learners want to retry even after wrong answers," directly linking interactive features of smartboards to increased motivation and sustained engagement. This aligns with literature that positions smartboards as tools that support active learning through quizzes, problem-solving, and real-time interaction (Bozzo et al., 2015). In this way, learners are not only exposed to content but are also actively engaged in iterative learning processes, where feedback and participation reinforce understanding. This reflects the broader pedagogical shift away from teacher-centred approaches towards learner-centred environments.

However, despite these positive perceptions, all participants reported feeling generally underprepared to fully utilise the capabilities of smartboards. For instance, Ratanang stated, "I'm prepared but limited by basic IWB features," and noted that "training was mostly independent learning through YouTube," bringing to light a significant gap between policy expectations and actual teacher preparation. Although national and provincial policies encourage ICT integration, (Matemera, 2020), the findings suggest that teacher education programme does not consistently provide structured, hands-on training on smartboard pedagogy. This supports existing concerns that pre-service teachers often enter teaching practice without sufficient competence or confidence to integrate technology meaningfully (Mavuru & Pila, 2021; Mihai, 2020).

Michael explained that he "can use IWBs for slides and gamification but has not explored their full capabilities due to lack of training," which reflects the limited pedagogical depth of ICT integration. This aligns with findings that PSTs often develop basic operational skills but lack deeper pedagogical integration aligned with learner-centred teaching approaches (Mihai, 2020). This limitation reduces the potential for optimal multimedia learning, as effective use of smartboards requires intentional design that supports dual-channel processing and active cognitive engagement.

Mentorship emerged as another significant factor shaping PSTs' experiences. Siboniso noted that "older teachers tend to use IWBs just to display textbooks, not actively integrating them into lessons," and that "mentors often reinforced traditional methods," highlighting how school-based mentorship can either enable or constrain innovation. This finding reflects concerns in the literature that PSTs' experiences during teaching practice are heavily influenced by the practices of mentor teachers, particularly when mentors themselves lack confidence in ICT integration (Mavuru & Pila, 2021).

Lerato observed that her mentor "rarely used IWBs, only to insert a USB," which restricted her exposure to interactive applications. This suggests a misalignment between the intended pedagogical affordances of smartboards and their actual classroom use. Although smartboards are designed to support multimodal learning, collaboration, and learner interaction (Alfaki, 2014), their underutilisation reinforces transmissive teaching approaches.

Contextual challenges further compounded these limitations. Participants cited frequent power outages, poor internet connectivity, and outdated or malfunctioning equipment. Michael explained that "when there are power cuts, I revert to handouts or draw diagrams manually," illustrating how infrastructural instability disrupts continuity in technology-enhanced learning. These challenges are consistent with broader South African studies that identify load shedding, technical faults, and limited support as persistent barriers to ICT integration in schools (Mkhwebane & Mbanze, 2026; Tefo, 2020). Such conditions not only hinder lesson delivery but also discourage experimentation with innovative pedagogies, thereby reinforcing reliance on traditional teaching methods.

In terms of support needs, participants called for comprehensive training programs—both technical and pedagogical—along with improved infrastructural resources. Lerato emphasized the need for "training on the board's features to effectively integrate them into lessons," highlighting that technical competence is a prerequisite for meaningful use. Siboniso stressed the importance of "pedagogical guidance on how to design active learning strategies with IWBs,". Ratanang advocated for "workshops and departmental involvement to better prepare teachers,".

5. Implications, recommendations and conclusions

The study found that pre-service teachers perceive smartboards as valuable tools for promoting active learning through enhanced engagement, collaboration, and differentiated instruction. They highlighted the benefits of multimedia features and gamification in supporting learner understanding and participation. However, their use of smartboards remains largely basic due to inadequate formal training, limited pedagogical support, poor mentorship, and infrastructural challenges such as power outages and poor connectivity, which restrict meaningful integration into teaching practice.

The main limitation of the study is the small, single-institution sample of five PSTs, which limits the broader applicability of the findings. In addition, the study captured only PST perspectives, excluding mentor teachers and learners, which could have provided a more comprehensive view of smartboard use in classrooms.

The findings point to the need to strengthen teacher education programmes by integrating both technical and pedagogical training on smartboard use, supported by improved mentorship and modelling of interactive practices during teaching practice. Future research should expand to multiple institutions and include mentor teachers and learners to deepen understanding of digital pedagogy in practice.

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THE APPLICATION OF ASSISTIVE TECHNOLOGY IN A SPECIAL PROGRAM FOR ACQUIRING COMPETENCIES IN ACTIVITIES OF DAILY LIVING

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Abstract

Assistive Technology (AT) is increasingly recognised as a key factor in supporting students with developmental disabilities, particularly in the context of acquiring competencies in activities of daily living. Despite a growing body of literature on the effects of AT, practical accounts of its application in special education programs remain scarce, hindering its implementation in everyday professional practice. The aim of this paper is to describe the diversity of assistive technology needs among students with multiple disabilities enrolled in a special program and to present practical ways to implement AT during group work, with an emphasis on the importance of individualised adaptation. The study was conducted at the Centre for Education and Rehabilitation Goljak in Zagreb. The participants were four students from an educational group aged 7 to 11 years with multiple disabilities. A needs assessment was carried out using the WATI (Wisconsin Assistive Technology Initiative) instrument, which is based on the SETT framework and covers communication, motor skills, sensory abilities, organisation, and leisure. Following the assessment, activities for acquiring daily living competencies were designed and implemented using available AT, including Big Points and Talking Brix2 communication devices, GoTalk4+, iTalk4, talking photo albums, switch-operated toys, and a tablet with ICT-AAC applications. Data were analyzed using a qualitative method. The results indicate significant heterogeneity in AT needs within the same educational group, confirming the need for an individualised approach. In all students, increased motivation for participation, longer sustained attention on tasks, and more frequent initiation of expressive communication were observed when using AT. The presented activities demonstrate that the same educational content can be acquired in different ways through various forms of AT, tailored to each student's motor, cognitive, and sensory abilities. The paper emphasises that implementing AT is not a one-time activity but a continuous, collaborative process that requires the professional competencies of educational rehabilitators, systematic assessment, and environmental support. In conclusion, the high-quality, individualised application of AT in special programs can significantly contribute to the development of functional competencies and to increased autonomy and quality of life for students with developmental disabilities.

Keywords: *Assistive Technology, special education program, activities of daily living, individualized approach.*

1. Introduction

Assistive Technology (AT) has been recognised as a significant factor in improving the quality of life of children with developmental disabilities and persons with disabilities (Blackhurst, 2005). Under the Technology Act of 1988, AT is defined as any item, piece of equipment, or product system, whether acquired commercially, modified, or customised, that serves to promote, maintain, or improve the functional capabilities of persons with disabilities (Individuals with Disabilities Education Act, as cited in Hersh & Johnson, 2008). A more accessible definition describes AT as a tool or strategy that enables a person to perform a task they would otherwise be unable to carry out at the expected level of performance (Parette & Peterson-Karlan, 2010). This definition is particularly applicable in the educational-rehabilitational context, where the aim is to bridge the gap between what a person wishes to do and what their existing environment allows them to do (Hersh & Johnson, 2008).

AT ranges from low-tech solutions (communication boards, picture symbols, adapted everyday objects) to mid-tech devices with speech output, and to high-tech systems such as eye-gaze technology and dedicated communication devices (Chambers, 2020; Cook & Polgar, 2015). When considering implementation, it is recommended to first explore the simplest solutions, as they are the most accessible, align with the learner's developmental changes, and are more financially viable (Chambers, 2020).

Globally, more than 2.5 billion people require one or more AT devices (WHO, 2024). Timely and appropriate use of AT can positively influence developmental outcomes, support the acquisition of functional competencies, and reduce dependence on others (Agree & Freedman, 2011; WHO, 2024). In the educational context, AT contributes to autonomy in academic and work-related tasks, more effective participation in classroom activities, more frequent interaction with peers, and the development of self-confidence and greater levels of motivation and attention (Copley & Ziviani, 2006; Fernández-Batanero et al., 2022). The integration of AT into educational activities is associated with higher levels of engagement and, consequently, better learning outcomes (Galeković, 2022).

In the domain of communication, augmentative and alternative communication (AAC) is particularly important, as it does not replace existing modes of communication but rather expands and supports them (Romski & Sevcik, 2005). For children with complex communication needs, AAC is a prerequisite for expressing a wide range of communicative functions that go beyond conveying basic needs, such as commenting, storytelling, and expressing abstract ideas (Moorcroft et al., 2019)

Despite the growing body of literature on the effects of AT, practical accounts of its application in special programmes are relatively rare, which hinders implementation in everyday professional practice (Pongrac, 2021; Stančić & Pinjatela, 2023). Inadequate assessment of needs, preferences, and priorities has been identified as the main factor in a poor match between the user and the technology (Scherer & Glueckauf, 2005), underscoring the importance of systematic assessment in selecting an appropriate form of AT. The aim of this paper is to describe the diversity of AT needs among pupils in a special programme for the acquisition of competencies in activities of daily living, and to present practical ways of applying AT in group work, with an emphasis on the importance of individualized adaptation.

2. Method

2.1. Participants

The study was conducted at the Goljak Centre for Education in Zagreb during April and May 2024. Non-probability purposive sampling was applied (Miles & Huberman, 1994). Four pupils from an educational group, aged 7 to 11, took part in the study. All pupils presented with multiple disabilities, including cognitive, motor, sensory, speech and language, and emotional and behavioural difficulties. The selection criteria were membership in a group in which the educational rehabilitator already uses or is considering using AT, and heterogeneity of diagnoses within the group, to encompass a range of needs. Ethical integrity was ensured through adherence to the Ethical Code (Committee on Ethics in Science and Higher Education, 2006), with the institution's approval and the written consent of the pupils' parents.

2.2. Assessment instrument

A needs assessment was conducted using the Wisconsin Assistive Technology Initiative (WATI) instrument (Gierach, 2009; WATI, 2018). WATI is based on Zabala's (1995) SETT framework (Student, Environments, Tasks, Tools), which integrates information about the learner, the environment, the tasks, and the tools. The instrument covers fourteen areas of assessment across twelve checklists, including seating and positioning, communication, computer access, motor aspects of writing, reading, mathematics, organisation, leisure, and vision and hearing. WATI was chosen for its comprehensiveness, systematic guidance throughout the process, and the possibility of subsequent outcome monitoring (Wong, 2018).

2.3. Procedure

Data were collected using structured observation (Ciesielska et al., 2017) under the supervision of the special education and rehabilitation specialist. Following the assessment, AT recommendations were formulated for each pupil, and activities to acquire daily living competencies were designed and implemented using available AT. The available AT included: Big Points communicators, Talking Brix2, GoTalk4+, iTalk4, talking photo albums, a talking mat, a daily visual schedule, a switch-adapted toy (Bubble Machine fish), and a tablet with applications from the ICT-AAC project (KuhARica, Prepoznaj pojmove, Učimo pojmove, Gibalica, e-Galerija, and Pisalica). Some of the devices were borrowed from the Laboratory for Assistive Technologies and Alternative and Augmentative Communication at the Faculty of Electrical Engineering and Computing, University of Zagreb. The data were analysed qualitatively.

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3. Results

3.1. Diversity of needs within the group

The assessment results confirmed marked heterogeneity of AT needs within the same educational group. Pupil A (9 years old) presents with cognitive and motor difficulties, as well as visual impairment. The pupil is non-verbal and communicates through vocalisations, gestures, and, to some extent, pictorial symbols. Given the visual impairment, recommendations include high-contrast pictorial symbols with clearly isolated backgrounds and enlarged dimensions, talking photo albums with auditory support, switch-adapted assistive toys, and the introduction of a lap tray on the wheelchair to bring materials closer to the pupil's field of view.

Pupil B (8 years old), who presents with features of autism spectrum disorder alongside cognitive, emotional and behavioural difficulties, shows a pronounced need for movement and frequent changes of position. It is recommended that the pupil continue using the communication board, with gradual expansion of the symbol set, a talking mat, and the iTalk4 with a linear key arrangement, as the GoTalk4+ grid layout is too demanding for this pupil. In addition, a T-stool or a ball chair is used to meet vestibular and proprioceptive needs during table-based work.

Pupil C (10 years old) presents with speech and language, cognitive, and motor difficulties, along with a diagnosis of epilepsy. Although the pupil verbally reproduces individual words, delayed echolalia is present, along with sensitivity to loud and cold auditory and tactile stimuli. It is recommended to mount tablet-based ICT-AAC applications on the wheelchair to compensate for the limitations imposed by fine-motor difficulties and stereotyped head movements, thereby providing a wider visual field and easier symbol selection. Musical and auditory components have proven to be strong motivators for this pupil.

Pupil D (8 years old), who is verbal but presents with speech and language difficulties, has been identified as having the potential for the introduction of a more complex communicator, such as the DialoQ Talk, and a tablet with ICT-AAC applications, all with the aim of supporting expressive language, initiating interaction with peers, and developing pre-reading and pre-writing skills.

3.2. Application of AT in group activities

The activities were designed to integrate several curricular areas, including self-care, communication, work education, creativity development, and socialisation. The activities themselves involved preparing pancakes, learning fruits and vegetables, distinguishing colours, identifying body parts, learning emotions, and pre-writing exercises.

In the food preparation activity, Big Points communicators were paired with specific food items and kitchen utensils, thereby supporting differentiation, naming, and multisensory acquisition of concepts. A talking photo album was used to display the sequence of steps in preparing the dish, and, in the unit on the body, to tell a simple story with auditory and visual support. GoTalk4+ and iTalk4 were used in the repetition and matching phases; for pupils for whom the grid arrangement of four symbols proved too demanding, the iTalk4 with a linear arrangement was used. Talking Brix2 was used in the active game "Day and Night", in which a non-verbal pupil with motor difficulties took on the role of issuing instructions to a peer, thus achieving active participation in joint play despite motor limitations. The switch-adapted toy functioned as a motivator for completing activities and as a means of supporting the development of understanding of cause-and-effect relationships.

The tablet with ICT-AAC applications proved to be a versatile platform. The KuhARica application, with the addition of a lap tray to facilitate scanning AR markers, was used to learn about fruits and vegetables. The Prepoznaj pojmove and Učimo pojmove applications were then used to revise colours and body parts, while the Gibalica application was used to develop coordination and body awareness. Finally, the e-Galerija application was used to create a story about emotions, and the Pisalica application for pre-writing exercises with the pupil who showed potential in this area. For pupils with more pronounced motor difficulties, the choice was adapted by reducing the number of offered images from three to only two and by using a Velcro strip with concrete objects as a more tactile interface.

During all activities, all four pupils showed increased motivation to participate, longer maintenance of attention on task, and more frequent initiation of expressive communication. Auditory feedback, in the form of praise from the applications and the playback of recorded sound clips on the communicators, consistently served as a strong motivator, enabling pupils to remain engaged in the activity for longer periods.

4. Discussion

The findings obtained corroborate those of earlier studies, which emphasise the diversity of AT users' needs and the necessity of an individualised approach (Ravneberg & Söderström, 2017; Scherer & Glueckauf, 2005). The fact that, within a group of only four pupils, needs were identified for AT devices of varying levels of complexity, ranging from low-tech pictorial symbols and talking mats to high-tech tablets with AAC applications, confirms the AT continuum as a functional concept in practice (Chambers, 2020). It was precisely the possibility of conveying the same educational content, such as body parts, emotions, or food items, through different technological formats that enabled the inclusion of all pupils, despite their differing abilities.

The observed increase in motivation and the more frequent initiation of expressive communication is consistent with the literature linking AT to greater independence, self-confidence, and social inclusion (Fernández-Batanero et al., 2022; Galeković, 2022; Stafford, 2005). It is important to emphasise that AT is not merely a set of devices but also includes so-called soft components, including services, training, support, and environmental adaptation (Cook & Polgar, 2015). The implementation of AT is therefore not a one-off activity but a continuous collaborative process, in which the competencies of special education and rehabilitation specialists, systematic assessment, and support from the family and the wider environment play a key role (Gierach, 2009; Lahm et al., 2001; Reed & Bowser, 2013). In the Croatian context, Pongrac (2021) and Stančić and Pinjatela (2023) highlight the need for additional training for professionals, specifically in AT assessment and implementation, a need likewise confirmed by the experiences reported in the present study.

The limitations of the study include the small number of participants, the short implementation period, and the inability to monitor the long-term effects of the recommended AT or to involve parents more systematically in the assessment process. For future research, a longitudinal design with outcome evaluation is recommended, along with the systematic inclusion of families across all phases of the SETT framework.

5. Conclusion

High-quality, individualised application of AT in special programmes for the acquisition of competencies in activities of daily living can make a significant contribution to the development of functional skills and to increased autonomy and quality of life for pupils with developmental disabilities. The examples presented demonstrate that the same educational content can be effectively conveyed through various forms of AT, with adaptations tailored to each pupil's motor, cognitive, and sensory abilities. A thorough assessment process, such as the one enabled by the WATI instrument, continuous professional support, and investment in the training of educational rehabilitators represent the key prerequisites for realising the full potential of AT in educational-rehabilitational practice.

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GRADE 10 SOUTH AFRICAN LEARNERS' EXPERIENCES DURING FACE-TO-FACE AND ONLINE LEARNING – IMPLICATIONS FOR SOCIAL INTERACTION

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Abstract

Learning in South Africa is characterised by unequal access and a diversity of cultures and languages within a single classroom, which influences social interaction. As technology becomes more sophisticated and readily available in classrooms, the question arises of whether digital tools influence social interaction to support learning. With Social Learning Theory being the primary lens, this study explored how South African grade 10 learners experience social interaction in face-to-face and online classrooms. In the context of multilingual, ongoing inequalities in resources and infrastructure, the study examined how modelling, feedback, and reinforcement differ across the two modalities. Learners from six schools were asked to complete a survey measuring teacher-learner interaction, peer interaction, classroom environment, technology-mediated interaction, and perceived social interaction in learning. Learners generally reported positive views across the variables above (M = 3.28–3.74). Face-to-face learners reported stronger peer interactions and teacher-learner relationships, as well as a more positive classroom environment, than those in online learning. Correlations showed a strong association between the classroom environment and both peer interaction (r = .61) and teacher-learner interaction (r = .51), whereas technology-mediated interaction was split into two factors. The logistic regression classified 84.4% of learners and identified peer interaction (B = -2.07, p = .002), age of the learner (B = -1.66, p = .27), home language (B = -0.96, p = .004) and repeated grades (B = -3.06, p = .006) as significant predictors of modality. This study makes a unique contribution by providing context-specific empirical evidence on how modelling, observation and reinforcement are supported in South African secondary schools. The study also highlights the vulnerability of peer interaction in online schools, the importance of the affective classroom environment for meaningful interaction, and the need for intentional design to recreate social interaction contexts in online classrooms. This study offers insights for curriculum planners, teachers and school leaders who plan to integrate technology meaningfully while maintaining the relational foundations of effective learning.

Keywords: *Social interaction, classroom atmosphere, teaching and learning relationships, secondary schools, technological tools.*

1. Introduction

Learning can be seen as a social process that involves shared meaning-making and interaction to construct knowledge (Vygotsky, 1978; Lave & Wenger, 1991). Hence, the quality of classroom interactions is important for learners' conceptual development (Hennessy et al, 2023). The participants in this study were grade 10 learners, in the adolescent developmental stage, which relies strongly on supportive relationships; the feeling of belonging must be considered to explain learners' motivation to participate in classroom activities (Wang & Eccles, 2012).

South African schools experience persistent inequalities in resources, infrastructure, and general learning conditions (Spaull, 2013). National policy in South Africa has promoted the use of ICT in line with the White Paper on E-education (2004) (Department of Education, 2004). However, implementation remains uneven, and technology-mediated learning is also disrupted by electricity instability (Mthanti, 2023).

The quantitative study was conducted in six schools, three face-to-face and three online, using a questionnaire completed by learners to measure perceptions of social interaction for teaching and learning. This study further highlights the central role of the classroom environment and the vulnerability of peer interaction in online learning environments.

The aims of the study were to describe the experiences of grade 10 South African learners of social interaction in face-to-face and online classrooms. And to examine how, within each modality, peer interaction, teacher-learner interaction, classroom environment, and technology-mediated interaction relate to one another and what the implications are for teaching and learning.

2. Literature review and theoretical framework

This study used Social Learning Theory as the primary lens, as it states that learning occurs through observation, imitation, modelling, and reinforcement in a social context (Bandura, 1977). Bandura (1977) further stated that new behaviours and ways of thinking can be observed in others (through modelling) and imitated. He further describes four processes which predict whether observational learning will result in performance, these include: attention (individual notices), retention (individual remembers what was observed), reproduction (individual enacts the behaviour), and lastly motivation (incentive to perform, including vicarious reinforcement) (Bandura, 1977). Clear modelling and observations, such as the teacher explaining work, peers working together, demonstrations and learning in an environment where feedback is visible, strengthen learning (Bandura, 1977; Roorda et al., 2011).

This study is concerned with social interaction and will draw on Moore's interaction framework, which distinguishes between learner-teacher, learner-learner, and learner-content interactions (Moore, 1989). These categories assist us in identifying where modelling and reinforcement opportunities occur in the classroom, e.g., teacher feedback, peer discussions, and in specifying how technology can enable or extend these interactions (Moore, 1989). To clarify the required conditions for meaningful participation in face-to-face and online classrooms, the idea of a community of inquiry can also be incorporated. The Community of Inquiry states that learning is a shared process that occurs when teaching, guidance, social presence, and cognitive presence work together in a learning environment (Garrison et al., 2000; Garrison, 2015).

Taken together, using Social Learning Theory as the primary lens, this study conceptualises social interaction as a classroom condition that creates (or restricts) opportunities for feedback, modelling and reinforcement (Bandura, 1977). Moore's interaction types and community inquiry clarify how these opportunities may differ across face-to-face and online teaching modalities (Garrison et al., 2000; Moore, 1989).

Teacher-learner interaction states that the teacher is the primary model who demonstrates, explains, and provides feedback to support learners' attention, retention, reproduction and motivation to participate in learning (Bandura, 1977). Evidence suggests that the affective teacher-learner relationship is associated with engagement and achievement, and supporting this relationship is central to learning (Roorda et al., 2011).

Peer interaction provides opportunities for vicarious learning by observing others and receiving social feedback. Peer interaction can provide modelling and vicarious reinforcement, thereby increasing learners' motivation to attempt and persist with tasks (Bandura, 1977). Peer interaction further strengthens learners' motivation to engage when they feel valued and respected (Furrer & Skinner, 2003).

Technology-mediated interaction is treated as either an enabling or a constraining condition for both modalities. Moore (1989) states that technology can amplify learner-teacher and learner-learner interactions through communication tools and can also influence learner-content interactions through resource design. Online communication is supported by synchronous and asynchronous lessons, chat functions, check-in classes, emails, feedback, and more, fostering a community where learners feel safe and motivated to interact.

The way tasks are designed influences interaction, since collaboration can be strengthened when the learning environment is designed to encourage interaction, and over-structuring hinders authenticity and limits interaction (Dillenbourg, 2002; Kirschner et al., 2004). Social interaction in South African classrooms is influenced by historical and structural inequalities, including persistent resource gaps (Chisholm, 2012; Spaull, 2013). The South African constitution further promotes mother-tongue basic education, which can be challenging when the language of teaching and learning differs from learners' home language, as language shapes participation and comprehension (Department of Basic Education, 2013).

3. Methods and data analysis

This quantitative research employed deductive reasoning, which proceeds from theory to hypothesis to structured, measured findings (Creswell, 2014). The qualitative approaches emphasise measuring variables as numeric data and using statistical procedures to examine patterns and relationships among variables (Creswell, 2005, 2014; Creswell & Creswell, 2023). In this study, the key variables were

social interaction and evidence of optimal teaching and learning, and the aim was to test their relationship using quantitative logic (Creswell, 2005, 2014). This study adopted a survey design to examine whether social interaction is associated with optimal teaching and learning across the modalities of online and face-to-face instruction, which is consistent with correlational quantitative designs (Creswell & Creswell, 2018). Survey research is appropriate for describing attitudes and perceptions and for efficiently testing associations between variables within a target population (Creswell & Creswell, 2018).

The sample comprised Grade 10 mathematics learners from three face-to-face and three online schools. Schools were selected based on accessibility and willingness to participate in the study. Online learners were distributed across South Africa, while the face-to-face learners were based in Gauteng. Online schools' instruction was in English, while face-to-face schools offered instruction in a mix of Afrikaans and English. Learners were asked to complete a questionnaire using a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree). The questionnaires were completed anonymously to protect learners' and schools' identities.

The data from the completed questionnaires were analysed with the support of the Statcon unit at the University of Johannesburg. Before the data was analysed, the learner responses were checked for any missing values or outliers. Once this was done, an exploratory factor analysis was conducted to evaluate the questionnaire and determine whether there are clusters of related items, as was observed with technology interaction (Tabachnick & Fidell, 2013; Hair, Black, Babin, & Anderson, 2019). Thereafter, the Kaiser-Meyer-Olkin (KMO) measure and Bartlett's test of sphericity were used to determine the suitability of the data for factor analysis (Shrestha, 2021; Hair et al., 2019). Factors with eigenvalues greater than one were retained (Kaiser, 1958; Shrestha, 2021), and where multiple factors were extracted, Varimax rotation was applied to improve interpretability (Shrestha, 2021).

Validity was ensured by measuring internal consistency and reliability of the data, calculating Cronbach's alpha (Cronbach, 1951; Tavakol & Dennick, 2011). While alpha is more commonly used, alternatives, e.g., omega, can also be used if they better match the measurement model (Hayes & Coutts, 2020).

4. Findings

The sample comprised 123 learners: 59 male (48%) and 62 female (50.4%), with 2 learners preferring not to disclose their gender. The learners were mostly aged 16-20 (84.6%), and 52.8% reported that English is their home language. The modality data were available for 122 learners, including 50 from face-to-face schools and 72 from online schools. Almost all learners reported having reliable internet access at home (98.4%).

The composite scale means for all factors were above the midpoint, which shows that learners generally held a moderate-to-positive perception of the factors. Normality testing indicated that the classroom environment did not deviate significantly from normality. However, the other composite scores showed departures from normality, as shown by the Kolmogorov–Smirnov and Shapiro–Wilk tests. Internal consistency reliability was moderate across most scales, with α=0.64–0.75, except for the two-item technology factor, which had α=0.47. Exploratory factor analyses support a largely unidimensional structure for most of its sets.

The correlation results indicated how the various variables of social interaction are related. There is a weak correlation between teacher-learner interaction and peer interaction, whereas there is a strong correlation between teacher-learner interaction and the classroom environment.

When analysing the logistic regression, peer interaction and learner background variables were the strongest predictors in the school mode. These findings suggest that social learning is not inherently tied to modality but rather depends on the extent to which peer interaction is supported and structured, particularly in online environments. The binary logistic regression can be seen below:

Table 1. Binary Logistic Predicting Schooling Modality (Online = 1, Face-to-face = 0).

Predictor	B (Regression coefficient)	Standard Error	Wald Chi-Square test	p	Odds Ration (Exp(B))
Age group	- 1.660	0.749	4.915	0.027	0.190
Home language	- 0.961	0.331	8.457	0.004	0.382
Repeated grades	- 3.060	1.124	7.411	0.006	0.047
Peer interaction	- 2.063	0.673	9.407	0.002	0.127
Technology interaction F1	0.787	0.420	3.511	0.061	2.197

5. Discussion

The findings of the study are consistent with Social Learning Theory, as learners in face-to-face classrooms reported stronger peer interactions, richer teacher-learner relationships, and a more positive classroom environment than those in online learning environments. The face-to-face learning environment naturally allows for stronger social presence and collaboration, due to immediacy and proximity (Garrison, Anderson, & Archer, 2000). The strong positive association between the classroom environment and the other interaction scales emphasises the importance of an affective classroom environment that enables meaningful social learning. When learners perceive the classroom atmosphere as supportive and encouraging, they are more likely to engage in the learning process by participating, collaborating, and engaging with peers and the teacher (Wentzel, 2017).

Learners in online classrooms, however, relied strongly on technology-mediated interaction and reported generally low interaction with peers. This finding correlates with international findings that online learning environments struggle to replicate the immediacy and behavioural cues found in face-to-face settings (Borup, Graham, & Davies, 2013). The findings also indicated that not all technology-based communication supports social presence equally, as seen with the two-factor technology scale. Peer interaction was a significant predictor of schooling modality, with higher levels associated with face-to-face learning. This further reinforces the idea that peer relationships are quite vulnerable in online learning environments and must be intentionally designed for (Hrastinski, 2009).

The demographic predictors, such as age group, home language, and repeated grades, also provide insights into learners across the different modalities and into why interaction patterns differ. Learners with home languages different from the language of teaching and learning were more likely to be in face-to-face classrooms. This may suggest that these groups rely more on linguistic code-switching or scaffolding, which is more feasible in face-to-face settings. The findings further align with research showing that academically vulnerable and multilingual learners require and benefit from high-support, high-interaction environments (Schleicher, 2019). Together, the study's results show that the instructional modality influences opportunities for social interaction and the types of learners who access and benefit from them.

These findings offer several practical implications for teaching and learning. The classroom climate should be prioritised as it is crucial for social interaction. A conducive classroom climate where learners feel they belong can be achieved by creating clear norms for interaction, which include communicating warmly and responsively (Wentzel, 2017). As the data suggests, peer interaction is one dimension in the online environment that is most fragile. To manage this, online schools should focus on creating and integrating opportunities where learners can collaborate, such as breakout rooms, peer feedback cycles, discussion forums, or small-group projects. Research shows that guided peer interaction can increase social presence and reduce the feeling of isolation in online environments (Garrison et al., 2000; Hrastinski, 2009). Since different technologies serve different purposes, teachers should incorporate tools that support dialogue, copresence, and other shared activities, rather than focusing solely on content-delivery technologies. The disconnection in the online environment is also present in teacher presence. The teacher should also be present in the lesson by being visible, providing timely feedback, and using multimodal communication to interact with learners and improve online engagement.

6. Conclusion

The study showed that learners reported generally moderate-to-positive perceptions of interaction and learning conditions in both face-to-face and online learning environments. Classroom environment and peer interaction showed the most consistent positive associations with perceived social interaction and learning, which suggests that the classroom environment remains central to learners' learning experiences. Technology-mediated interaction was also separated into two dimensions, with only one aligning with social-learning variables. The findings suggest that learners' learning experiences depend more on the teacher and school structure than on the modality itself (face-to-face or online).

For South African schools, facing multilingual and cultural differences, the emphasis must be on practices and technologies that intentionally support peer interaction and vulnerable learners while recreating a conducive learning environment. Ultimately, enhancing social interaction across modalities is essential for fostering meaningful learning experiences and ensuring that learners can participate fully, regardless of the platform they use.

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SPACED LEARNING IN SECONDARY SCHOOL: A CROSS-BORDER TEACHING PROPOSAL

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Abstract

Spaced learning is a teaching methodology that structures time to optimize students' attention, concentration, and long-term memory consolidation. Kelley and Whatson (2013) developed this approach to investigate whether delivering brief inputs at structured intervals could facilitate the encoding of complex information into long-term memory. This methodology frames the educational setting as a dynamic environment capable of fostering students' active engagement and metacognitive awareness. Building on these premises, this study aims to design and test a spaced learning pathway within upper secondary education, specifically targeting core subjects in vocational institutes for food and wine services and hospitality. The objective is twofold: to enhance learning outcomes in vocational subjects and to promote inclusion and school well-being, which are central to educational quality and academic success. The five-phase educational intervention comprises three cognitive input sessions interspersed with two breaks featuring distracting activities. Within this framework, motor activity plays a strategic role, supporting knowledge consolidation by integrating bodily experience with cognitive processes. This approach is particularly relevant from an inclusive perspective, as it may prove especially effective for students with special educational needs, fostering a more accessible, participatory, and motivating learning environment. Operationally, the pathway alternates lesson time with ten-minute sessions of motor activities and interactive games, aiming to support a more effective, relaxed, and meaningful learning process. Applying spaced learning to vocational subjects in food and wine studies and hospitality is thus intended not only to strengthen technical skills but also to positively influence participation, inclusion, and perceived well-being. The experimental research will be conducted over two years, involving a sample of 500 students equally distributed between Italy and Tunisia. Through this comparative and transnational perspective, the study seeks to analyze the methodology's effectiveness across different educational contexts, contributing to the scientific debate on innovative teaching strategies oriented toward academic success, inclusion, and the promotion of well-being at school.

Keywords: *Inclusion, physical activity, school well-being, spaced learning, upper secondary school.*

1. Introduction

In recent years, the pedagogical debate has increasingly focused on developing teaching methodologies capable of effectively responding to the complexity of contemporary educational contexts, with particular attention to learning quality, inclusion, and school well-being. From this perspective, spaced learning represents an innovative approach based on a specific temporal organisation of teaching and learning activities, aimed at optimising attention, concentration and long-term memory consolidation. As highlighted in the theoretical framework of the project, the spacing format adopted was defined based on empirical evidence and the model proposed by Kelley and Whatson (2013), in dialogue with the teachers involved in the experimentation. The experimental project AMIE' (*Apprendre en mouvement pour l'inclusion à l'école*) is situated within this theoretical and methodological horizon and aims to optimise and implement spaced learning in the core subjects of vocational institutes for food and wine services and hotel hospitality. The project involves Italian and Tunisian schools and is promoted and coordinated by the research group of the University of Palermo, Department of Psychology, Educational Science and Human Movement (SPPEFF). It aims to test a teaching methodology and evaluate its impact on learning, verifying its effectiveness and efficiency in educational contexts, with particular attention to upper secondary education. The project arises from a holistic approach to the educational-training process, grounded in a careful reading of educational needs and the need to promote truly meaningful learning through the support

of neuroscience. From this perspective, this paper presents the theoretical foundations, research design, and evaluation framework of the project, highlighting its pedagogical and scientific value. As the research is still ongoing, the text does not report final results but offers an articulated reflection on an experiment that seeks to integrate disciplinary learning, motor activity, inclusion and well-being into a unitary framework.

2. Theoretical framework

Spaced learning is based on the idea that the temporal organisation of teaching activities significantly affects information encoding and retention. In this direction, Kelley and Whatson (2013) helped define a model based on the repetition of brief cognitive inputs, interspersed with distracting breaks, to facilitate long-term memory consolidation. Within the AMIE' project, this model has been reinterpreted from an educational perspective and contextualised in upper secondary school through an operational structure shared with teachers. Further theoretical contributions help explain the logic of spacing. Karpicke and Bauernschmidt (2011) distinguish between absolute and relative spacing, arguing that a greater overall interval between repetitions can improve information retention. Carpenter et al. (2012) also emphasise that different forms of spacing can support learning and long-term memory, while Cepeda et al. (2006) show that longer retention intervals and more frequent repetitions increase the likelihood of correct recall. The project incorporates these theoretical indications, while recognising that excessively long intervals may lead to forgetting and reduce the method's effectiveness. A distinctive aspect of the AMIE' proposal is the integration between spaced learning and motor activity. Based on the studies of Gomez Paloma, Ianes and Tafuri (2017), the project foresees that the breaks are filled with motor exercises, physical activity and body movements. This choice fits into an embodied view of learning, according to which the body is not an accessory element of the educational process but a constitutive dimension of knowledge construction. From this perspective, the shift from teacher-centred direct instruction to student-centred experiential learning fosters understanding, application of knowledge in authentic situations, and personalised learning. The project also adopts a clear inclusive perspective. It aims to verify the implications of spaced learning also for students in difficulty and/or with disabilities, in the belief that methodological innovation should be evaluated not only in terms of cognitive effectiveness but also regarding its capacity to make the school environment more accessible, participatory and motivating. In this sense, inclusion and well-being are not accessory dimensions but core components of educational quality.

3. Research objectives

The general aim of the research is to initiate a reflection on the school context in order to: compare the applicability, generalisation and transferability of alternative methodologies compared to ordinary ones; verify the efficiency of the research programme in improving learning outcomes and measures of equity and inclusion; develop pedagogical-didactic recommendations and operational guidelines useful to inform future policies and actions in the field of education and training. Based on these aims, the project intends to: promote meaningful learning in the core subjects of vocational institutes for food and wine services and hotel hospitality; verify the effectiveness of spaced learning in upper secondary school contexts; analyse the impact of the integration between cognitive inputs and motor activity; evaluate the effects of the intervention in terms of inclusion and school well-being; observe the transferability of the model from a comparative and cross-border perspective between Italy and Tunisia.

4. Methodology and research design

The project adopts an experimental design articulated in several phases. An initial preparatory phase is aimed at defining the general operational framework. This is followed by a design phase of approximately three months, dedicated to the operational formulation of hypotheses, identification of variables of interest, sample selection, and definition of timing and instruments. The model implementation, testing and experimental verification phase develops over approximately six months and includes the administration of initial tests, shared re-modulation of the intervention, and the implementation of the training pathway. Subsequently, an outcome evaluation phase of approximately four months is planned, followed by a final phase, also of approximately three months, dedicated to drafting the final report and disseminating the research results. The project also includes a training and co-construction action with teachers, initiated through seminars at the partner schools and accompanied by periodic moments of reflection, sharing, and re-modulation of activities. Data collection is structured into three main moments: an initial baseline, carried out through pre-test disciplinary tests; a teacher training phase on the spaced learning methodology, based on its neuroscientific and methodological-didactic foundations; and a data

collection and analysis phase at the beginning and end of the application of the innovative methodology. In addition, an anamnestic questionnaire is administered to teachers to collect information on the context, characteristics of the classes, and the possible presence of students with special educational needs. The research involves a sample of 500 students, equally distributed between Italy and Tunisia, thereby assuming a strong comparative and transnational value. This choice allows not only to verify the effectiveness of the model in different educational contexts but also to reflect on its transferability to school systems characterised by different cultural and organisational conditions.

5. Structure of the teaching intervention

From an operational point of view, the project has identified that activities developed with the spaced learning method are particularly suitable when carried out in two consecutive hours per day. The adopted format foresees two distracting breaks of 10 minutes every 30 minutes of lesson, for a total duration of 120 minutes. On this basis, a scheme for structuring lesson units and teaching activities was built together with the teachers. The protocol is organised into five phases, comprising three input moments and two breaks. In the first input phase, the teacher presents the information that students are expected to learn during the lesson. This phase lasts 30 minutes. It is followed by a 10-minute break during which no reference is made to the content covered; motor proposals are intended to distract from the didactic moment through physical activation. In the second input, also lasting 30 minutes, the teacher takes up and re-elaborates the previously presented content. Subsequently, a second break is inserted, structured according to the same logic as the first. Finally, in the third input, the teacher maintains the focus on the content of the first session, and students can demonstrate that they have acquired the knowledge transmitted, apply it in practical exercises or problem-solving situations, and ask questions. Although well defined in its temporal structure, this format leaves room for flexibility. The teacher can adapt the intervention methods to the needs of the class and the specificities of the subject matter, calibrating the lesson to promote active learning and interaction, while remaining within a rigorous methodological framework.

6. Assessment instruments

A particularly relevant element of the project is the breadth and multidimensionality of the evaluation framework. Starting from the analysis of the literature, the project has foreseen specific instruments for measuring inclusivity and well-being, motor abilities, cognitive abilities, and disciplinary skills. For the assessment of inclusivity and well-being, the following instruments are used: the Perceived Stress Scale (Cohen et al., 1983), the Pittsburgh Sleep Quality Index (Buysse et al., 1989), the Satisfaction With Life Scale (Diener et al., 1985), the Trait Meta-Mood Scale-24 (Salovey et al., 1995), the Short Form Health Survey (Ware et al., 1996), the WHO-5 Well-Being Index (World Health Organization, 1998), the Positive and Negative Affect Schedule (Watson et al., 1988), the questionnaire on inclusive quality (Ferrara, 2021), and the Multicage-TIC (Pedrero Pérez et al., 2018). These tools allow to detect perceived stress, sleep quality, life satisfaction, emotional regulation, quality of life, psychological well-being, affective states, inclusive quality of the context, and problematic use of technologies. Motor abilities are measured using the International Physical Activity Questionnaire (Craig et al., 2003), while cognitive abilities are assessed through the Metacognitions Questionnaire-30 (Wells & Cartwright-Hatton, 2004) and the reduced Learning Strategies Questionnaire (Pellerey, 1996). Finally, for the analysis of disciplinary skills, specific tests related to practical and theoretical competences in cooking and restaurant service, as well as gastronomic history, have been developed. This framework appears highly coherent with the project aims, as it allows evaluating the impact of the intervention not only on disciplinary learning but also on cognitive, motor, emotional, and inclusive dimensions.

7. Towards the experimentation: theoretical and methodological openings

The AMIE' project appears particularly significant for at least three reasons. First, it applies spaced learning to a still scarcely explored sector, namely upper secondary vocational education. Second, it integrates the spacing methodology with motor activity, attributing to the body a structural function in the learning process. Third, it places inclusion and equity dimensions at the centre of the intervention, recognising that educational quality cannot be reduced to cognitive performance alone. The project also shows awareness of the limitations and criticalities associated with the application of spaced learning. The document highlights, in fact, that the methodology requires teachers to invest more effort in planning, special care in classroom management, and the availability of spaces, materials, and technological tools that are not always present in schools. Among the weaknesses mentioned are the risk of confusion during breaks in large classes and the increased workload for lesson preparation. However, this methodological

awareness reinforces the scientific robustness of the project. Attention to teacher training, the rigorous structuring of the protocol, the plurality of evaluation instruments, and the comparative dimension between Italy and Tunisia confer significant potential to the research, both empirically and in terms of pedagogical reflection. The project proposes a theoretically grounded and methodologically structured experimentation of spaced learning in upper secondary education, with particular reference to vocational institutes for food and wine services and hotel hospitality. The intervention integrates repeated cognitive inputs, motor breaks, and a multidimensional assessment of outcomes, with the aim of promoting meaningful learning, inclusion, and school well-being. Although the research is still ongoing and no final data are yet available, the project already offers a relevant contribution to the debate on innovative teaching methodologies. It suggests that spaced learning may constitute not only a technique for improving memory consolidation but also a lever for rethinking the relationship between teaching, body, participation, and the quality of school life. In this sense, the cross-border perspective between Italy and Tunisia further broadens the scope of the research and strengthens its scientific and pedagogical relevance. Future empirical findings will allow to verify the effectiveness of the model and to refine the operational recommendations for teachers and policymakers.

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WORKSHOPS

TAMING CHATGPT (AND OTHER AI BEASTS): DESIGNING A GENAI CODE OF CONDUCT FOR MEANINGFUL LEARNING

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Abstract

More than three years after the paradigm-breaking release of ChatGPT 3.5 in November 2022, many higher education institutions still struggle to position themselves towards GenAI. They are understandably reluctant to embrace tools that allow students to outsource cognitive processes and potentially bypass key learning outcomes. Yet a blanket ban is not realistic either, as GenAI is rapidly becoming indispensable in professional practice. Many institutions have therefore gravitated towards general policies calling for "responsible use." Well-intentioned as these may be, they often leave students uncertain about what is permitted. Some avoid GenAI altogether for fear of misconduct, while others use it liberally, creating uneven learning conditions. Moreover, generic policies may clash with teachers' intended learning outcomes: GenAI may undermine the learning value of some tasks while enriching it for others. What is needed is a clear and precise, yet flexible, framework that adapts to varied learning objectives while remaining consistent across courses. A customizable GenAI Code of Conduct — a document with a fixed structure but adaptable elements — offers such a solution. In this workshop, participants will explore how to develop and implement such a code collaboratively, ensuring student support and staff buy-in rather than imposing a top-down policy. Through discussion, collaborative critique, and hands-on guided design activities, we will explore effective content and formatting, drawing on a code co-developed by the engineering faculties of KU Leuven and Hasselt University (Belgium). Participants will leave with a first draft tailored to their particular context and a clear pathway to build support and integrate it across their faculty.

Keywords: *Generative Artificial Intelligence, ChatGPT, technology in education, educational policy, higher education.*

1. Introduction

The public release of ChatGPT in November 2022 sent shockwaves across numerous sectors, not least higher education. It was immediately evident that generative AI (GenAI) would become profoundly impactful; far less clear, however, were the mechanisms through which that impact would unfold, the speed at which changes would materialize, and the approaches educational institutions should adopt in response. The uncertainty surrounding GenAI's rapid evolution even led to the publication of an open letter by the Future of Life Institute (2023), urging developers to pause further GenAI development until adequate safeguards could be established. Unsurprisingly, competition urged developers to keep pushing out ever more powerful large language models at an astonishing rate, while universities, structured to respond methodically and deliberatively to pedagogic change, were struggling to keep up.

The most straightforward policy response available to higher education institutions was to simply prohibit the use of generative AI tools by students and to maintain existing pedagogical and assessment practices. However, such an approach is now widely regarded as untenable for at least two reasons. First, students are likely to continue using these tools regardless of formal prohibitions, particularly in the absence of reliable and valid detection mechanisms (Weber-Wulff et al., 2023). Second, the ability to use GenAI tools effectively and responsibly is increasingly viewed as a relevant professional competence, with employers expecting graduates to be conversant with AI-supported workflows (Waring, 2024). A blanket ban could therefore compromise the employability of students, or at the very least, disconnect higher education from evolving workplace realities. Conversely, an overenthusiastic, unrestricted adoption of GenAI tools is equally problematic. Allowing unlimited use would enable students to delegate core cognitive activities—such as analysis, synthesis, and problem-solving—to an external, artificial intelligence, thereby eroding the very learning processes that universities should cultivate. Moreover, an

uncritical adoption of generative AI would introduce a whole range of additional risks, including threats to academic integrity, to the development of critical thinking skills and creativity, as well as concerns related to privacy and equity.

In response to these competing pressures, many universities have converged on a more nuanced position. Drawing on so-called soft law policy frameworks developed by organizations such as the OECD (2023) and UNESCO (2023), institutions now typically permit the use of generative AI, provided it is applied ethically, fairly, and transparently, aligned with intended learning outcomes, and does not adversely affect students' learning processes. However, such high-level guidelines often remain abstract and insufficiently operationalized. While they articulate important normative principles, they frequently fail to provide students with the practical means to distinguish between appropriate and inappropriate use in concrete learning contexts (Dabis & Csáki, 2024). This lack of instrumentalization generates considerable uncertainty among students. Because the guidelines are not readily actionable, students interpret them differently: some adopt a cautious stance and refrain from using GenAI tools for fear of penalties or accusations of fraud, while others engage more liberally with GenAI tools. The ambiguity inherent in many GenAI policy statements could result in a situation of educational inequity: under ostensibly uniform rules, differences in interpretation (and risk tolerance) could translate into unequal assessment outcomes.

In many universities, this problem is addressed by delegating responsibility for more detailed guidance to individual course instructors. Institutions such as Stanford, Princeton, and Harvard explicitly instruct students to follow course-specific policies regarding the use of GenAI tools (Giugliano, 2025). While this approach allows instructors to align GenAI use with disciplinary norms and specific learning outcomes, it also introduces a degree of variability. Across a curriculum, students may encounter markedly divergent—and sometimes conflicting—expectations, leading to confusion and policy fatigue. What is called for, then, is a coherent institutional framework: a shared, recognizable policy document that offers sufficient uniformity to ensure clarity and fairness, while remaining flexible enough for course instructors to be adapted to the particular learning objectives and assessment demands of individual tasks.

2. Objectives

The aim of the workshop is to engage participants in critical reflection on both the form and content of such a policy document, and to support them in developing a draft version of a "GenAI Code of Conduct" tailored to their specific institutional or disciplinary context. This code is intended to remain sufficiently flexible to align with the learning outcomes of particular courses, while maintaining a coherent and recognizable structure across contexts. Additionally, the workshop aims to have participants reflect on how to ensure student and faculty buy-in for the introduction of such a document.

3. Workshop proceedings

Participants will be seated at small group tables to facilitate interaction and hands-on collaboration. Following a brief introduction by the workshop facilitator, participants will first engage in a structured exchange of experiences and current practices related to students' use of generative AI. This initial discussion will address whether guidelines are currently provided, the level of detail of such guidelines, how they are communicated or enforced, and to what extent these approaches are perceived as effective. Participants will also reflect on common challenges, such as students' adherence to guidelines, the volume and nature of student questions regarding usage of GenAI tools, and how instructors respond when they suspect that large language models have been used in ways that were not intended.

Building on this exchange, participants will then reflect on both the form and content of a policy document designed to bridge the gap between high-level institutional principles—such as academic integrity, equity, and fairness—and the concrete, task-specific questions students encounter when using GenAI tools. Central guiding questions include how such a document can maintain a recognizable structure across contexts while remaining adaptable to diverse courses and learning outcomes, and which guidelines are essential and non-negotiable within a GenAI Code of Conduct.

In the subsequent phase of the workshop, participants will be introduced to the GenAI Code of Conduct developed jointly by the Faculty of Engineering Technology at KU Leuven and Hasselt University. They will be invited to critically assess this document and to identify elements that would require modification or elaboration to fit their own institutional, disciplinary, or pedagogical contexts.

Participants will then work – collaboratively if possible - to develop a draft version of a GenAI Code of Conduct tailored to their specific needs and contexts. These drafts will be peer feedbacked and discussed critically.

The workshop will conclude with a plenary discussion on issues of acceptance and implementation, focusing on strategies to ensure that both students and staff recognize, understand, and adopt the proposed Code of Conduct.

4. Conclusion

This workshop helps bridge the gap between high-level GenAI policies and the practical questions students and instructors face in everyday practice. By working collaboratively on a flexible GenAI Code of Conduct, participants translate abstract principles into clear, usable guidance that can be adapted to specific courses while remaining consistent across a program or faculty.

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SAVING THE PLANET BY SAVING ENVIRONMENTAL EDUCATION. WHAT CAN ARTS-BASED PEDAGOGY OFFER?

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Abstract

Climate change has produced the hottest summers, worst droughts, wildfires and flooding ever recorded. Yet, Environmental Education (EE) and Education for Sustainable Development (ESD) have largely failed to generate levels of eco-literacy and citizen action necessary to address the climate crisis. In this interactive workshop the aims, systemic policies and pedagogy of EE and ESD are critically examined using a paired and snowballed group activity. Participants from all educational disciplines (maximum 32) and all age phases are welcome. Pairs are given a statement about aims, policies and practices of EE and ESD to debate, and then join a pair who have debated a corollary of that statement. As groups of four, emerging issues about relative effectiveness of EE and ESD approaches are argued and summarized by the workshop leader. Examples of Arts-Based Pedagogy (ABP) are shown that address issues emerging from group feedback. Participants work in pairs on different questions providing foundations for research to explore how ABP in EE might operate at different levels of the educational system. Participants leave with a sense of how the educational research and teaching communities might work together to help reinvigorate Environmental Education, providing routes for young people to act responsibly for sustainable futures. At a time when the turn to neoliberal populism is taking hold, threatening greening actions, this workshop is most timely. Bringing Environmental Education back to core principles of working for social justice, environmental protection, and addressing climate change are essential priorities for saving the planet.

Keywords: *Environmental education, sustainability, arts-based pedagogy.*

1. Introduction

In this workshop we critique ways in which the shift from Environmental Education (EE) to Education for Sustainable Development (ESD) has stripped away some of the more humanizing elements of EE that, ironically, functioned well for what ESD is trying to achieve, in terms of personal sensitization towards the environment and to stimulate environmental action and improve social justice. The objective of the workshop is to explore how employing methods of Arts-based Pedagogy (ABP) might show how teaching communities can reinvigorate Environmental Education, providing routes for young people to act responsibly for sustainable futures and at the same time stimulate educational research.

With roots in 18th and 19th Century romanticism and nature study, Environmental Education became established in the global North in the late 20th Century and by the early 1980s had become established as a cross curricular element in many countries (Braund, 2025; Palmer, 1998). A common framework for EE emerged promoting teaching and learning '***Through***, ***About*** and ***For*** the Environment'. The idea was that learners would experience environments (through), gain knowledge and understanding (about) them, that would lead to action required to improve, conserve or campaign (for) the environment. In effect the 'about' part of this triumvirate dominated at the expense of the other two with much content learning established, often in science and geography lessons. Commenting on the status of EE in the late 1990s, Steve Van Matre critiqued the *through*, *for* and *about* approach as becoming, "a bit of everything to everyone and consequently not much of anything to anyone" (Van Matre, 1999, p. 46). Contemporaneous with development of EE and in reaction to it, Van Matre and others promoted a more learner-centered approach which they called Earth Education (see, Braund, 2025, pp. 52-55). Earth Education reasons that, when one is too full of one's own thoughts, one cannot make room so easily for the impressions of the other life around oneself and so nonverbal skills like watching and waiting, silencing and stilling, opening and receiving come to the fore. While not wholly promoting an arts-based approach, Earth Education activities lend themselves to it. In this workshop the author draws on experience of teaching EE through Earth Education at a teacher education college in the UK where many Arts-based approaches were developed.

2. The rise and critique of education for sustainable development

Emerging as part of the UN's decade of sustainability (2005-2014), ESD began to be established in schools in many counties, eventually subsuming or even replacing EE. While the aim of ESD in terms of fairer distribution of resources, living within sustainable means and with social justice as principal foci are hard to argue against, there have been criticisms that ESD shows theoretical weaknesses and political and ideological bias compared with the relatively rich historical development for EE (Cartea, 2005). Cartea sees ESD as something of an attraction, even an obsession, or just an aesthetic, which connects with a certain 'neo-liberal' environmentalism rather than providing attainment of justice and equity at a more personal, community and therefore local level.

It is from this critique of ESD that we reimagine the relationship between EE and ESD in the initial stages of the workshop through a paired card activity. Pairs are given a positional statement about EE and ESD to discuss such as, "Environmental Education was such a vague idea that teachers had no idea what to teach or how to teach it. At least Education for Sustainable Education has clear aims, and it is on-trend to help save the planet." Pairs then migrate to a pair who have discussed a corollary of that statement such as, "*Education for Sustainable Education* – who knows what that means? At least Environmental Education had a clear idea of teaching *About, Through and For* the environment." The ensuing discussion highlights some of the issues about ESD including Cartea's critique and that learners find concepts of ESD abstract and hard to grasp and may have personal alienation from ESD principles, leading them to say such things as – "why should I be involved?" – "Isn't it just governments who should sort all this out."

3. Arts-based pedagogy and environmental education

In a recent review of the literature on ESD, Gagen finds that teaching about the facts of environmental degradation and climate change dominate and concludes that, "teaching people of any age climate facts alone, to fill a perceived gap in knowledge, is not the best climate-communication strategy for achieving action" (Gagen, 2025, p. 34). Gagen goes on to posit that, "there is much to be learned from stepping away entirely from a science-based approach to climate communication and exploring the climate emergency through arts and creative lenses" (Gagen, 202:41). It is at this stage of the workshop, that we delve into examples of how this might be achieved.

3.1. Examples of arts-based pedagogy (ABP) for environmental education

In a recent book on language arts and EE the author provided a list of arts-based methods that can be used to address EE principles and reconnect youth with personalized experiences of and for environments, along the lines of Earth Education: creative writing, dance, drama, drawings, fabric, films, models, music, literature, natural samples (for example leaves, mud, rocks, soil and wood), painting, photographs, poetry, sculptures and videos (Braund, 2025, p. 49).

In the workshop we look specifically at a selection of approaches discussing how each provides contact with issues that help young people establish a more personalized learning and appreciation of their locale so that broader issues of climate change, degradation, conservation and pollution are manifestly addressed.

From experiences with education students at a university college in the UK, the author relates how he led a group of graduate students to empathize with the environment using circle games (see Braund, 2025, pp. 52-53). Also exampled are role-play dramas such as survival games, ephemeral art arrangements of fallen leaves and experiences at a Finish Nature School of Earth Education activities, such as creating an aesthetically pleasing, yet representative littoral ecosystem, in a jam-jar.

4. A discussion on arts-based capital for environmental education

The idea of 'capital' is often associated with life chances of individuals. Bourdieu (1986) conceived people's cultural capacities, being able to engage with the diversity and richness offered by society, linked with background and informal (social-family), or institutional (education-based) experience. It is worth noting that most of Bourdieu's writings were about the cultural capital derived from activity in arts and humanities arenas rather than from science and environmental activity and experience. More recently Archer et al. (2015) have expanded on Bourdieu's ideas of capital considering how these might extend to the language, values and activities that they see as cultural capital in science. In the workshop I argue for an expansion of the concept of cultural capital for science to embrace creativity and aesthetics afforded by arts-based pedagogies (ABP). The ASPIRES project (Archer et al., 2015) suggests science capital is strongly influenced by social and familial relationships and practices linked to socio-economic

status. I suggest that arts capital is more naturally evident and arguably easier to come by, in the lives of young people, than science capital and so less likely to be linked with socio-economic status.

5. Researching arts-based pedagogy (ABP) for environmental education

From issues emerging from the workshop, participants are presented with a series of possibilities for research. Each of these is discussed in terms of how these might be enacted:

1. To what extent do ABP approaches in EE/ESD help learners access ideas in multilingual classrooms?
2. Does using ABP to teach environmental education impact personal environmental actions?
3. What are age-appropriate strategies for using art in environmental education?
4. What are the progression steps in learning using ABP in environmental education?
5. What are learners' and teachers' predispositions to using ABP in EE/ESD?
6. What are learners' and teachers' reactions to having used art-based approaches in EE/ESD?

6. Conclusion

There is little doubt that climate change is now more than an existential threat. It is a systemic problem of such scale and complexity that fundamental and transformative changes to society's systems are required, implying fundamental and transformative changes to EE. The workshop provides opportunities to think more deeply about how ABP contributes to improving Environmental Education. From our workshop it emerges that in the turn to ESD, with its very laudable aims, the personalized education gained from best applications of EE and Earth Education have been lost. Biesta (2022) calls for a change of educational priorities, putting students as emotionally sensitized and environmentally aware individuals to the foreground. The big issues facing the future of our planet often seem over-facing and so using arts-based pedagogies offer a way of rekindling EE at a much more personal level, drawing on the arts-based capital that many young people possess. If we really want realistic changes in behavior and lifestyle choices, then connecting at local and community levels is a priority. Also important is to engender a sense of critical eco-literacy. In the last few months, we have seen a significant turn away from a commitment to net-zero (carbon emissions) to address climate change. Partly, this trope is being fed by Right Wing Populism, fueled (most notably by the Trump MAGA rhetoric) and by eco-skepticism on anthropogenic climate change. The world needs future generations equipped with good environmental knowledge, but who are not afraid to challenge neoliberalist agendas and want to act because they care about what happens to the places they have come to value and love. In this workshop we see how ABP has power to refocus EE to provide personal connections for young people to turn more naturally towards sustainable behaviors and challenge eco-skepticism.

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FACILITATING CLASSROOM DIALOGUE IN SEXUALITY EDUCATION THROUGH GAME–BASED LEARNING AND GENAI

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Abstract

The purpose of this workshop is to explore how the content of human-to-human interactions compares to human-to-GenAI interactions, in the context of facilitating dialogue on topics related to Comprehensive Sexuality Education (CSE). CSE varies greatly between countries but generally fails to connect meaningfully to pupils' lived experiences. We introduce a new educational tool – the SexEdTalk card game – that facilitates open and age-appropriate conversations about sexuality in a safe, scientifically grounded, yet playful way. The game aims to foster: i) knowledge about sexual topics; ii) mutual understanding, respect, and empathy; and iii) insights into ideologically normative constructs and their consequences. It includes four decks: "Let's find out", 40 questions and answers; "Situations", 30 hypothetical experiences to discuss how to help or overcome difficulties; "True or False", 40 sentences to dismantle sexual myths; and "Let's talk about…", 10 keywords on specific topics often avoided. Because young people nowadays often turn to GenAI chatbots for advice on sexual topics, ChatGPT is introduced in the workshop as a virtual interlocutor. ChatGPT's answers and feedback will then be compared to those of the workshop participants and evaluated regarding: i) factual correctness; ii) social awareness and empathy; and iii) embedded ideological constraints or constructs. Based on these findings, participants will reflect on the broader pedagogical and ethical implications of using a GenAI tool as a persona to spark, moderate, or enrich class discussions. The workshop is designed for teachers working with students aged 14 and over and will include a maximum of 20 participants.

Keywords: *Sexuality, card game, ChatGPT, educational tool, teachers.*

1. Introduction

Sexuality Education (SE) is defined as a lifelong learning process and a right since early childhood (UNESCO, 2018; WHO & BZgA, 2010), supporting healthy development and preventing abuse (Bruno, 2024; Putri, 2022; Schneider & Hirsch, 2020). A comprehensive SE (CSE) aims to challenge the stereotype that sexuality is equal to sexual intercourse including topics related to sexual rights, sexual identities, emotions, consent, respect, body development, and healthy behavior to promote knowledge, increase skills, and foster positive attitudes toward all sexualities; moreover, it aims to adapt the contents to the different students' ages and to the individual's development to guide people in their sexual exploration and to provide a safe and healthy approach to their own and others' sexuality (Goldfarb & Lieberman, 2021; Hawkins, 2024; Jiménez-Rìos et al, 2023). The CSE's preferred setting is the school environment, where it shares educational responsibility with families; however, only a few countries have laws supporting CSE in schools, leading to inadequate knowledge and the perpetuation of cultural false myths about sexuality (IPPF, 2018; UNESCO, 2023). In-service teachers perceived a lack of knowledge, strategies and educational tools regarding sexual topics, along with discomfort when facing students' questions or problematic situations (Ang & Lee, 2017; Bruno et al., 2024; Klein, 2021).

While for some CSE means teaching sensitive and challenging topics, for many it is necessary to develop crucial skills for daily life. CSE has three objectives: to increase and improve knowledge and skills, enabling recipients to apply their knowledge, and finally, to foster positive attitudes. Although CSE should align with sexual development, the earlier the start, the better the results (Advocates for Youth, 2009), there is a common belief that adolescence is a more suitable age for discussing sexual topics. Teachers consider adolescence the most feasible and accessible period to address CSE, provide support for first sexual

experiences, and prevent risks (Cortina-Lopez et al., 2021; Leung et al., 2019). This leads to CSE's implementation more frequently in middle or high schools and to engage in discussions on sexual topics with adolescents or after puberty (Johnson-Motoyama et al., 2016; Joseph et al., 2021).

In the present work, sexuality is considered an integral part of life experience, considering all its aspects – sociocultural, moral, ethical, psychological, emotional, and biological – that can influence and be influenced by personal beliefs, experiences, and life context (WHO & BZgA, 2010). Acknowledging the difficulties of teachers, but also parents and whoever would like to address CSE topics that suffer a lack of shareable guidelines and materials, a game was developed for adolescents – the SexEdTalk card game – to support the communication and education on sexual topics based on the importance of discussing them in an open, playful and interactive context (Alencar et al., 2022; Fioretti, 2023; Hoyle & McGeeney, 2020).

2. Game design

The first and second authors designed the SexEdTalk card game to help people who wish to address CSE topics with people aged 14 and over. The card game includes 121 cards: specifically, one for simple game instructions and then four decks to respond to different goals. The first deck is called "Let's find out" and contains 40 cards with questions and answers in terms of information on CSE topics to increase scientific and accurate knowledge; following, there is the "Situations" deck, including 30 cards on hypothetical experiences – personal or of others – to discuss what someone could do to help or overcome difficulties and to help develop awareness, skills and positive attitudes. The third deck is for acknowledging the personal and cultural false myths on sexuality: the "True or False" deck includes 40 direct sentences to assess the knowledge or the presence of sexual false myths. Finally, there is the "Let's talk about" deck, which comprises 10 keywords to include specific topics often avoided and to let people know about them. Each deck is designed to invite open and honest communication, and each card provides a scientific answer to help facilitate the discussion or offer final feedback.

3. Workshop objectives

The SexEdTalk card game was designed in Italian and then translated into English to test its effectiveness during the workshop, specifically regarding participants' reflection on and discussion of their knowledge and opinions. Furthermore, the workshop aims to examine the contribution of ChatGPT, as such chatbots have become one of the main conversation partners for young people on topics related to sexuality. While these chatbots – detached as they are from any real and direct social context – may offer a seemingly "safe" space for asking questions about sensitive issues, it remains unclear to which extent they function as empathetic, constructive and error-checking interlocutors. Given their documented inclination for sycophancy, chatbots may allow potentially harmful notions to go unchallenged. Also, their equally well-documented training biases may have them confirm rather than question ideologically normative constructs of sexuality. Therefore, this workshop aims to investigate i) the factual correctness of ChatGPT's answers; ii) its social awareness and capacity for empathy; and iii) potential ideological constraints.

4. Approach

Participants will be asked to reflect on the topics, their knowledge and the game's pros and cons. Furthermore, they will be asked to select some cards and check how ChatGPT answers, considering whether the answer is correct or not, and taking notes on any eventual questions, doubts, or thoughts on how they would like to continue the conversation with other people, students and ChatGPT. Finally, by critically discussing the correctness of ChatGPT answers, the workshop would open to an active sharing moment of opinions and thoughts on ChatGPT's usefulness as a moderator or active participant in the discussion.

5. Conclusion

While no definitive conclusions can yet be drawn, this work in progress suggests that combining participatory gameplay with the critical use of ChatGPT may open new possibilities – and questions – for engaging GenAI tools in sexuality education.

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A CASE STUDY ON TRAUMA-INFORMED CULTURALLY RESPONSIVE TEACHING: CORE CONCEPTS FOR SCHOOL PROFESSIONALS

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Abstract

Purpose: This workshop addresses the critical need for educators and helping professionals to develop competencies in supporting students affected by adverse childhood experiences (ACEs), intergenerational trauma, and socio-political adversities. Participants will acquire practical skills in implementing trauma-informed and culturally responsive (TICR) approaches within educational settings. *Background:* The workshop integrates the National Child Traumatic Stress Network's 12 Core Concepts for Understanding Traumatic Stress Responses (12 CCs) with SAMHSA's trauma-informed principles. Through problem-based learning (PBL), participants explore ecological factors influencing trauma response and recovery while developing strategies to mitigate secondary traumatic stress among educators and helping professionals. *Key Points:* Participants will: (1) apply the TICR framework to diverse educational contexts; (2) analyze multisystemic trauma impacts on student response and recovery; (3) consider risk and protective factors across ecological systems; and (4) identify TICR strategies to support educators, helping professionals, and students. *Methodology:* The 45-minute workshop employs a structured PBL approach comprising three phases: (1) didactic presentation introducing TICR framework and 12 CCs; (2) small-group case analyses using one case vignette and applying select CCs as analytical lenses for critical reasoning and case conceptualization; (3) small-group synthesis of insights and opportunities for participants to apply TICR framework to their own settings. *Participants:* Educational professionals including teachers, counselors, social workers, psychologists, and administrators. Maximum of 40 participants, ideally seated in groups to maintain optimal small-group dynamics.

Keywords: *Trauma-informed, culturally responsive, problem-based learning, secondary trauma.*

1. Introduction

It is reported that about 70% of people are exposed to potentially traumatic events (PTEs) in their lifetime (Kessler et al., 2017, as cited by the World Health Organization, 2024). Children, families, and communities respond differently to PTEs. Some forms of trauma are associated with more negative impacts, such as war, violence, sexual trauma, and complex trauma, i.e., multiple trauma exposures. Other factors associated with negative outcomes include insecurity related to basic needs and lack of adequate mental health and health care services. Social-ecological factors found to promote resilience include social support, food and housing security, and access to mental health services and affirming care (Satapathy et al., 2022).

Given the ubiquitous nature of exposure to PTEs, educators are likely to have students in their classrooms who have experienced trauma. These students may experience various trauma responses that impact their behavior in the classroom including hyperarousal (e.g., agitation, startle responses), hypo-arousal (e.g., avoidance, emotional numbing, tuning out), re-experiencing symptoms (e.g., poor sleep quality, nightmares, intrusive thoughts, flashbacks), and avoidance of sensory input (e.g., physical sensations, sights, sounds, smells, tastes), thoughts and feelings that may act as trauma reminders. When responding to a trauma trigger in the classroom, a child or adolescent may move rapidly from a regulated state to a dysregulated state (Saxe et al., 2016).

Educators may also have experienced their own history of trauma, including ACEs, domestic violence, intimate partner violence, sexual trauma, racial trauma; and/ or shared trauma such as community violence (including school violence), disasters, and war. When educators learn about students' exposure to trauma, they may be reminded of their own trauma histories and/ or experience symptoms of secondary traumatic stress (NCTSN, 2012).

2. Purpose

The purpose of this workshop is to address the critical need for educators and helping professionals to develop competencies in supporting students who have experienced adverse childhood experiences (ACEs) (Anda et al., 2006) such as abuse, neglect, witnessing domestic violence, food or housing insecurity, and other exposures outside of the family (e.g., community violence, bullying, disasters, refugee trauma, deportations).

This workshop integrates the National Child Traumatic Stress Network's 12 Core Concepts for Understanding Traumatic Stress Responses in Children and Families (12 CCs) (NCTSN, 2012) with an adaptation of the U.S. Substance Abuse and Mental Health Services Administration's (SAMHSA, 2014) guidance for trauma-informed care. The NCTSN's 12 CCs describe the complex impacts of trauma that children, adolescents, and their families commonly experience and were developed as part of a larger curriculum to train graduate students, helping professionals, and educators in childhood trauma (Dublin et al., 2025).

While the CCs aim to increase understanding about childhood trauma and its impact, SAMHSA (2014) delineates principles essential to trauma-informed care, including "safety, trustworthiness and transparency, peer support, collaboration and mutuality, and [acknowledgement of] cultural, historical and gender issues" (p. 10). We have adapted the latter principle (cultural, historical, gender) to include cultural and gender responsiveness and move beyond awareness of "issues" or a problem-centered approach to a trauma-informed and culturally responsive (TICR) approach.

3. Workshop aims

This workshop aims to increase participants' understanding of the impact of individual, historical, and/ or shared trauma on students while focusing on strategies that support emotional regulation, build upon student strengths and resilience, and co-create a safe and culturally responsive environment in the classroom (Sherwood et al., 2021).

This workshop applies the 12 CCs (NCTSN, 2012) as an important tool for educators to increase their understanding of the ways in which children, families, and communities are impacted by trauma, integrated with a TICR approach to build on student strengths and resilience leading to more effective outcomes in the classroom. Participants will acquire practical skills in implementing trauma-informed and culturally responsive (TICR) approaches within educational settings. Through problem-based learning (PBL), participants explore ecological factors influencing trauma response and recovery while developing strategies to mitigate secondary traumatic stress among educators and helping professionals.

3.1. Workshop structure and plan

The workshop will include up to 40 participants who will be assigned to work in small groups of five members. Handouts will be provided to include the 12 CCs, case vignette, and resources. The following outlines the workshop plan:

1. The workshop will begin with a brief overview, introduction to the TICR framework, the NCTSN 12 CCs and SAMHSA's principles for trauma-informed care (10 minutes).
2. A PBL case-based, practice-oriented approach will be introduced with a brief case vignette (5 minutes)
3. Small group activity (1): Groups will identify how one preselected CC applies to the facts of the case, with 2 groups sharing 1 CC so that overall, 8 groups will cover 4 CCs (10 min). This assignment may vary depending on the total number of participants.
4. Small group activity (2): Group members will apply the TICR approach and SAMHSA principles to their own educational/ practice settings (10 minutes).
5. Learning assessment/ large group shout outs: Participants will be invited to share take aways from their learning with the large group (10 minutes).
6. A resource handout will be provided that participants may bring back to their organizations for further discussion and implementation.

3.2. Learning outcomes

By the end of this workshop, participants will be able to:

1. Identify and describe key elements of the TICR approach, the NCTSN 12 CCs, and SAMHSA's principles for trauma-informed care, as demonstrated through active participation in small group activities.
2. Apply at least one NCTSN CC to a case and analyze how the CC applies to the facts.

4. Evaluation

A brief evaluation using three Likert-scale questions will be provided at the end of the workshop. The evaluation will assess participant perceptions of the relevance of content, quality of presentation, and likelihood to apply information in the presentation about trauma-informed and culturally responsive education in a professional setting. QR code will be projected on the screen which will link to a digital version of the evaluation, which participants may access with their phones. Print copies will also be placed on the tables.

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