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THE CONTRIBUTION OF STEM EDUCATION IN CREATING AUTHENTIC LEARNING AND ASSESSMENT ENVIRONMENTS IN K-12 EDUCATION

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Abstract

STEM education can contribute to the creation of authentic learning and assessment environments, as STEM activities foster practical engagement, integrate technology and innovative tools, promote a multidisciplinary approach, link different scientific fields, and enhance critical thinking and creativity among students. The aim of this research was to investigate the extent to which STEM is applied by teachers in primary and secondary education in Greece and how it contributes to authentic learning. It is crucial that teachers are well-prepared and equipped to support students in attaining higher levels of understanding, which can provide them with academic opportunities in science and technology. Through authentic learning, students construct their own knowledge in realistic environments. Furthermore, authentic settings emphasize the social nature of knowledge, which benefits student comprehension and application. Instead of memorizing information, students learn how to learn through hands-on experiments and simulated exercises. By engaging in complex, open-ended problems, students develop skills, search for information, and use critical thinking to solve challenges. They actively participate in practical activities, monitor their progress, and evaluate their final work based on specific criteria that provide a summative assessment of their learning. The aim of this study is to investigate the degree of STEM implementation in primary and secondary education and STEM's contribution to the creation of authentic learning and assessment environments. Fifteen teachers, mostly members of the Hellenic Education Society of STEM, participated in this study. Semi-structured interviews were conducted, and qualitative analysis was used to identify key themes related to how STEM promotes authentic learning and assessment. The initial themes that emerged from the data analysis include the degree of STEM implementation in K-12 education, the contribution of STEM teaching to authentic learning and assessment and barriers to creating authentic learning and assessment environments in STEM teaching. Additionally, the study identified key challenges that teachers face in implementing STEM education, including limited access to STEM resources, a lack of flexibility in developing STEM curricula and the necessity for professional development opportunities that do not infringe on teachers' time. Participants emphasized the importance of securing dedicated time for professional development to prevent teacher burnout and ensure the effective implementation of STEM learning. The shortage of resources, training, and teacher support were highlighted as significant obstacles in creating authentic learning and assessment environments through STEM education. Addressing these challenges can help ensure the broad-scale implementation of STEM education. This research underscores the importance of children receiving adequate STEM education in order to be prepared to thrive in a professional environment seeking executives literate in 21st century skills. Moreover, creating supportive environments for teachers is essential to facilitate the effective integration of STEM into the curriculum.

Keywords: *Authentic environments, authentic learning, authentic assessment, STEM.*

1. Introduction

1.1. Conceptual definition of authentic learning

The core principle of authentic learning is that students engage more effectively when acquiring new knowledge and skills through hands-on experiences rather than traditional theory-based instruction (Chiu et al., 2018). Authentic learning deliberately integrates interdisciplinarity, enhances critical thinking, strengthens argumentation skills, and improves pattern recognition. Research suggests it also fosters the development of strong STEM identities (Singer et al., 2020).

1.1.1. Characteristics of authentic activities. Authentic activities simulate real-world scenarios rather than predefined classroom exercises. These activities present complex problems without straightforward solutions, requiring students to use interpretation, critical thinking, and initiative to find solutions (Herrington et al., 2003; Mims, 2003).

1.2. Conceptual definition of authentic assessment

According to Wiggins (1990), authentic assessment is a "genuine test" of intellectual achievement, requiring deep understanding, higher-order thinking skills (HOTS), and complex problem-solving through the execution of meaningful tasks. As an alternative assessment method, it evaluates 21st-century skills by ensuring active student participation, realistic contexts, and multifaceted evaluation criteria (Khalil & Osman, 2017).

1.3. STEM epistemology

STEM education represents an innovative approach to science learning, emphasizing self-regulated learning and the development of metacognitive skills, critical reasoning, and creative thinking. It aligns with constructivist principles, encouraging students to actively shape their learning process (Kalpana, 2014; Ilman Anwari, 2015; Adom et al., 2016). STEM environments connect schools to the global workforce, enhancing students' competitiveness (Widana et al., 2021).

1.3.1. Skills developed through stem implementation. A comprehensive understanding of STEM principles allows students to analyze, apply, and integrate concepts to address complex challenges, devise innovative solutions, and enhance real-world connections. STEM education fosters digital literacy, communication, data analysis, task management, and cybersecurity awareness (Stehle & Peters-Burton, 2019; Widya & Rahimi, 2019; Lavi et al., 2021).

1.3.2. Prerequisites and advantages of STEM implementation. Designing an interdisciplinary STEM curriculum with authentic assessment requires significant effort, time, and collaboration among stakeholders. Educators increasingly trust STEM's pedagogical approach, reflecting confidence in its educational impact (ElSayary, 2021).

1.3.3. Assessment in STEM environments. Authentic assessment in STEM interdisciplinary curricula targets cognitive, psychomotor, and affective learning domains, ensuring a comprehensive educational approach (ElSayary, 2021). Educators' ability to develop authentic STEM-based assessments is influenced by creativity and proficiency in information technology, which is becoming a mandatory competency in modern education (Widana et al., 2021).

2. Design

This qualitative research was conducted in two stages. Initially, extended literature research took place to highlight epistemology and potential problems. In the second stage of the research semi-structured interviews were conducted with 15 teachers, mostly members of E3STEM which were analyzed using thematic analysis. The aim was to investigate the extent to which STEM education is implemented in K-12 and possible ways that this implementation could contribute to the creation of authentic learning and assessment environments.

3. Objective

There were three equally important objectives in this study. The first two were to examine the extent of implementation of STEM education in primary as well as in secondary education. The final objective was to investigate the ways in which STEM contributes to the creation of authentic learning and assessment environments.

4. Methods

The research utilized Google Scholar and ResearchGate, employing keywords such as authentic learning, authentic assessment, STEM, problem-solving, rubric assessment, (e-) portfolio, and 21st-century skills.

Following the literature review, four research questions were formulated, each aligning with one of three key axes. The first axis examines STEM implementation in primary and secondary education.

The second explores STEM's role in fostering authentic learning and assessment environments. The third investigates the barriers educators face in STEM implementation.

The formulated research questions are the following. Research question 1: Can STEM education contribute to the creation of authentic learning environments in primary and secondary education? Research question 2: Can STEM education contribute to the development of authentic assessment environments in primary and secondary education? Research question 3: In which way can STEM education contribute to the creation of authentic learning and assessment environments? Research question 4: What barriers do educators face in creating authentic learning and assessment environments through STEM education?

Each research question was explored through specific interview questions, tailored to participants. To address these research questions, interviews were conducted with 15 educators, mostly members of the Hellenic STEM Educational Association (E3STEM). Participants reviewed and signed an informed consent form before agreeing to be interviewed. An interview protocol was developed to guide the process and ensure consistency in data collection.

Figure 1. Interview Protocol.

Table 1. Interview Protocol

"Creating Authentic Learning and Assessment Environments through STEM Activities in Primary and Secondary Education"

Question Categories	Question Objectives	Thematic Axes	Interview Questions
General Questions	Introduction to the educator and exploration of their relationship with STEM.	- Academic Background - Teaching Experience - Experience in STEM Education	1.What is your field of expertise? How many years have you been working as an educator? 2.How many years have you been involved with STEM education? 3.Have you received any training or further education in STEM?
The Value of the STEM Perspective in Problem-Solving	Identifying experts' perspectives on the value of STEM in problem-solving.	- STEM Perspective - Problem-Solving Approach	1. What is the value of the STEM perspective in problem-solving?
The Significance of STEM Education at the Curriculum and Teaching Level	- Investigating participants' views on the significance of STEM education at both the curriculum and instructional levels. - Gathering information on what a STEM educator needs to implement at	- Curricula - STEM Teaching Methods - School Textbooks – Multiple Books Approach - Student's Book (Instructional Content) -Teacher's Guide (Methodological Guidelines – Assessment Elements) - Worksheets -Additional Teaching Materials	1. How are curricula and school textbooks connected to STEM teaching? 2. What are the necessary actions for a STEM educator?
The Relationship Between STEM Activities and Authentic Learning	Identifying educators' beliefs regarding the relationship between STEM activities and the achievement of authentic learning.	-Understanding the concept of authentic learning. -Examining educators' attitudes toward	1. What does authentic learning mean to you? How would you define it? 2. Do you believe that authentic learning is effectively implemented within the current education system? 3. Do you think STEM activities contribute to achieving authentic learning?

5. Data analysis

The data collected from the semi-structured interviews were transcribed and analyzed using thematic analysis. Initially, the transcriptions were coded to identify key themes and concepts, while significant statements were also noted within the texts. Through this process, ten codes were developed and subsequently grouped into three broader thematic categories. The analysis focused on identifying recurring patterns and connections between participants' experiences and challenges related to STEM implementation.

6. Findings and discussion

The study revealed that STEM education is more widely implemented in secondary schools, whereas primary education faces greater difficulties due to resource limitations and structural constraints. Teachers expressed enthusiasm for STEM-based learning but reported significant challenges, including the lack of necessary materials, curriculum rigidity, and limited institutional support.

STEM education significantly contributes to authentic learning by linking theoretical knowledge to practical applications, fostering active problem-solving and critical thinking. Authentic assessment methods, such as project-based evaluations, portfolio assessments, and observational analysis, provide a holistic view of student progress, measuring not only comprehension but also collaboration, critical thinking, and innovation skills.

Despite its benefits, the study identified key barriers to successful STEM integration, including resource shortages, restrictive national curricula, and a lack of specialized training for educators. Without adequate professional development, teachers may struggle to design and facilitate engaging STEM activities aligned with authentic learning principles.

Without adequate professional development opportunities, teachers may struggle to design and facilitate engaging STEM activities that align with authentic learning principles.

7. Conclusion

STEM education has the potential to transform traditional learning by fostering authentic engagement and assessment, equipping students with essential skills for future academic and professional success. However, its full implementation is constrained by structural limitations such as inadequate teacher training, resource shortages, and curriculum rigidity. Addressing these challenges through targeted professional development programs, increased resource allocation, and greater flexibility in curriculum design is essential for the successful integration of STEM education in schools. Future research should expand the sample size of educators, examine the long-term impact of STEM-based curriculum reforms, and identify best practices for overcoming existing barriers. By addressing these issues, STEM education can effectively contribute to meaningful, authentic learning experiences that prepare students for the demands of the 21st-century workforce.

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