

THE ROLE OF STEM IN DATA-DRIVEN LEARNING IN THE SOCIAL SCIENCES

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Abstract

The digital age has precipitated profound changes in all aspects of human life, with education being no exception. Contemporary learning is characterised by increased interactivity, collaboration and a focus on the student as the central element of the educational process. Within a comprehensive educational framework, STEM plays a pivotal role in cultivating a foundation of theoretical and applied knowledge. The objective of the present study was to analyse the implementation of an educational approach based on Science, Technology, Engineering, and Mathematics (STEM) concepts for teaching in the Social Sciences (STSS) through data-driven learning (DLL). The focus was on the development of disciplinary content and science skills as outlined in the curricula of the degree programmes that are part of the STSS. The present study entailed a thorough review of the curricula of the Social Sciences (SS) degrees programmes, with the objective of ascertaining the proportion of STEM subjects included in the curricula. The data collection technique employed involved the retrieval of curricula, with the objective of conducting a comparative study and determining the impact of STEM on the education and outcomes of STEM students. The findings provide an overview of teachers' knowledge of STEM, as well as the development of students' scientific skills through the empowerment of ABD techniques.

Keywords: *Data-driven learning, STEM, creativity, science skill.*

1. Introduction

Nowadays, learning has become more interactive, collaborative, and student-centered. Through a comprehensive education, STEM plays an important role in the formation of the background of theoretical and applied knowledge and data-based learning.

Within the STEM model, several researchers have identified the following challenges: 1) The demand for proposals based on new theoretical-methodological precepts based on coexistence with student data (real or everyday situations (Murillo, 2013); 2) The appropriate combination of a greater solidity of STEM knowledge with the pedagogical theories and specific methodologies of the Social Sciences (SS) (Uzurriaga, 2013); 3) The construction of authentic situations of the Stem-everyday binomial (Rodríguez, 2013), to promote a better predisposition and motivation of students, as well as a greater appreciation for the usefulness and value of STEM content.

These challenges mean the need for a change of course around curricular design in the different degrees of the university education system, in order to influence the use of STEM methodology, which entails some difficulties, due to the fact that, in general, the curriculum is usually closed and inflexible (García & García, 2020).

However, it is possible to observe subjects that promote the integration of multidisciplinary contents: such as Basic Statistics, Multivariate Statistics, Experimentation and Simulation and Modelling of the Reality in which the students' activity takes place. In addition, it includes a training path related to digital technologies in which the study of software for the study of STEM content such as R, ChatGPT (among others) and applications related to the coexistence of data is incorporated.

This work includes, in addition to the introduction, a second section on the problem statement, a third section on the review of the state of the question and a fourth section on methodological discussion and evidence. The fifth section includes an analysis of the evidence related to the inclusion of STEM content in the curricula, to finally point out the limitations and conclusions.

2. Statement of the problem

In an increasingly technological and digital society, the verification of certain shortcomings in the STEM education of university students is one of the problems faced by the higher education system. The relevance of this problem is based on the fact that STEM education has become a fundamental pillar in the training of university students, as it prepares them for the knowledge society.

It is an educational approach that integrates four pillars: Science, Technology, Engineering and Mathematics, focused on learning based on the handling and management of large amounts of data, aimed at generating questions and questioning in the student, encouraging their creativity and allowing them to develop essential skills for the 21st century, such as critical thinking, problem-solving and digital skills.

STEM education improves the development of skills and knowledge through the integration of STEM subjects into the curricula of bachelor's and master's degrees and the development of teaching strategies based on the examination, design, analysis and interpretation of the data with which it coexists.

3. State of the art

In the digital age, the concept of education has evolved significantly thanks to the integration of Information and Communication Technologies (ICT), Learning and Knowledge Technologies (TAC) and Technologies for Empowerment and Participation (TEP). From this perspective, STEM education as a learning tool in a world that coexists with data has the task of preparing students to face the academic and labor challenges of the digital age.

By STEM education we mean that which promotes the integration and development of scientific-technical subjects in a single interdisciplinary framework with a didactic approach that guarantees the transversality of the teaching-learning process through science, technology, engineering and mathematics (Science, Technology, Engineering and Mathematics).

STEM training explores how communication and learning technologies redefine teaching and learning methods, becoming an essential requirement in contemporary education. The detailed exploration of STEM content in curricula allows the relevance of these contents to be evaluated in the generation of analytical, filtering and discrimination competencies of data and information and encourage active participation in student learning.

It is about understanding the impact of STEM on the educational context and on the skills of handling new technologies and how its content can be used to enrich the learning experience.

STEM education ensures that the use of "Learning and Knowledge" technologies improves and optimizes teaching and learning processes in the higher education space. That is, it develops competencies aimed at facilitating the acquisition of knowledge, skills and competencies, using digital resources such as simulations, collaborative learning platforms and interactive multimedia resources and, more recently, intelligent tutors.

STEM content makes it possible to incorporate new knowledge, skills and competencies into the students' background knowledge, through the creation of more participatory and motivating learning environments, which stimulate the generation of questions and questions, as well as the necessary motivation for the academic and professional technological empowerment of students.

In the 21st century, the teaching of STEM content represents a fundamental change in the way the teaching-learning process is conceived, pointing towards a more interactive model based on the extraction of information from the coexistence with data, and prepares students not only to overcome academic challenges, but also to thrive in a digital world.

Bybee (2013) conceives STEM as a concept that can be defined at different levels, so that we can talk about an approach, model, initiative, educational groups, policies, programs and even teaching practices of a STEM nature. This flexibility is not exempt from some criticisms, however, precisely because the use of the term has been applied with some freedom to different areas, in this sense Bybee (2013) points out that in order to be able to speak of a STEM approach or strategy, it is necessary to include some characteristics, such as the integration of knowledge, competencies and skills in the solution of a problem-situation or in the analysis of large volumes of data.

Other authors, such as García Cartagena et al. (2017, 19), mention that STEM education, within the context of integrated sciences, is understood as an approach to the teaching of science, technology, engineering and mathematics, in an interdisciplinary way, where the rigor of scientific knowledge is developed through immersive didactic activities applied to the real world.

This type of learning, which is generated under this approach, is present within all disciplines of the Social Sciences, and has been considered by various authors (Mansilla, 2010; Martín-Páez et al., 2019) as interdisciplinary learning that, in terms of Tomalá-Vera (2024), involves a process in which students

understand and assimilate different knowledge and ways of thinking from various disciplines that are integrated to achieve a new background of concepts, processes, skills, and attitudes.

That is, it would not only be about knowing or representing data, but also about testing hypotheses, also about arguing, discussing, proposing ideas, or conducting experiments. These last actions have also been identified as a fundamental part of STEM teaching.

From this perspective, learning should provide opportunities for students to develop reasoning, inquiry, argumentation, and reflection skills (Barrera et al., 2021; García & García, 2020). Moreover, this STEM approach can contribute to responding to current economic and social challenges, specifically by identifying the needs of jobs and professions to adjust new skills to job requirements, emphasizing current technological and environmental challenges.

Hence, the construction of formalized knowledge includes activities such as solving problems, inquiring, experimenting, obtaining answers, making demonstrations, posing new questions, among others. This type of procedure also includes errors, difficulties, reframing of questions, etc. The question then arises as to why not transfer these principles to teaching-learning in the SS.

This conception of education makes it possible to identify the need for learning that takes into account the formalization, with a solid theoretical basis, of the interdisciplinary or multidimensional knowledge of SS students.

4. Methodology and empirical evidence

In this research, we carried out a review of the curricula of SS degrees to determine the proportion of STEM subjects included in these plans. The data collection technique used was the recovery of the curricula to carry out a comparison between grades and establish the impact of STEM on the training and results of SS students. The findings offer an overview of teachers' knowledge of STEM, as well as the development of scientific skills in students through the empowerment of ABD techniques (see Table 1).

A first result shows that there are some extreme outlier degrees such as Law whose study plan does not include any ECTS STEM credits and Applied Statistics whose study plan includes 85% of credits related to STEM knowledge.

We also observe that the range of variation of STEM knowledge fluctuates between 5% and 25%, which implies a relatively low level of credits taught of STEM knowledge in the Social Sciences. Among the degrees with the lowest proportion of STEM knowledge are: Tourism, Social Work, International Relations, Journalism, Pedagogy, Management and Public Administration, Social Education, Criminology, Political Science and Social and Cultural Anthropology.

While 10% of the Bachelor's Degrees that teach the most STEM knowledge are made up of the Bachelor's Degrees: Business Administration, Finance, Banking and Insurance and Information and Documentation.

In general, it is possible to conclude that there is a clear deficit in the STEM training of Social Sciences students, with the exception of certain Bachelor's degrees focused on Statistics and Data Science.

*Table 1. Proportion of ECTS Credits of STEM Knowledge in the Bachelor's Degrees in Social Sciences (SS).**

Proportion of ECTS Credits of STEM Knowledge in the Bachelor's Degrees in Social Sciences (SS)*		
Bachelor's Degrees in Social Sciences	ECTS credits	% of total credits
Business Administration	60	25,0
Social and Cultural Anthropology	18	7,5
Applied Data Science	150	62,5
Political science	18	7,5
Commerce	42	17,5
Audiovisual Communication	30	12,5
Criminology	12	5,0
Business Administration UCM - HWR, Berlin	47	19,6
Bachelor's Degree in Fashion Design and Bachelor's Degree in Commerce UPM-UCM	30	12,5

Bachelor's Degrees in Social Sciences	ECTS credits	% of total credits
Economy	42	17,5
Community education	12	5,0
Applied Statistics	204	85,0
Finance, Banking & Insurance	60	25,0
Geography and Spatial Planning	36	15,0
Management and Public Administration	12	5,0
Information and Documentation	60	25,0
Pedagogy	18	7,5
Journalism	18	7,5
Advertising & Public Relations	24	10,0
International relations	12	5,0
Labor Relations and Human Resources	6	2,5
Sociology	36	15,0
Social work	12	5
Tourism	18	7,5
* Public universities in Spain offer similar degrees with similar plans of studies		

5. Limitations

Authors such as Bogdan and García (2021, 70) comment that one of the limitations related to the conceptualization of STEM as a curricular integration of four disciplines is the lack of greater empirical support to support the didactic effectiveness of this educational approach. Also the limited sample used, given that the universities that offer Bachelor's Degrees include private universities, which are not part of this pilot sample.

6. Conclusions

The STEM approach has become increasingly important in the international educational field, because it has characteristics that make it possible to integrate different elements of the four components that make it up into a learning task for the classroom.

In relation to the STEM knowledge taught in the different Bachelor's Degrees in Social Sciences, there is a clear deficit in their curricula. In general, the range of STEM credits taught in most Bachelor's Degrees fluctuates between 5% and 25%.

There is a wide dispersion between the different degrees in the inclusion of STEM knowledge in the curricula of the different degrees offered in the Social Sciences, with the exception of the degrees in Applied Statistics and Data Science, which are focused on data-based learning and the use of technological tools.

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