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STUDENT AND TEACHER PERCEPTIONS OF LEARNING ENVIRONMENTS UNDER THE STEM APPROACH

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ABSTRACT

This study analyzes student and teacher perceptions of STEM-based learning environments for natural sciences at two public educational institutions in the Colombian Caribbean region. Using a quantitative design, 128 11th-grade students and teachers were surveyed to characterize socioeconomic factors, attitudes toward science, and institutional conditions for the implementation of STEM-based educational strategies. The findings reveal a generally positive attitude among students toward the natural sciences, although this is limited by factors such as low family income, limited availability of technology at home and in institutions, and a lack of adequate laboratory resources. Teachers also identified deficiencies in infrastructure, equipment, connectivity, and pedagogical appropriation of the STEM approach. It is concluded that, despite the willingness of students and teachers to strengthen science learning, there are significant structural barriers that hinder the effective implementation of integrative and contextualized learning environments.

KEYWORDS: Learning Environment, STEM Approach, Natural Sciences, Secondary Education.

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1. INTRODUCTION

The STEM approach, which encompasses Science, Technology, Engineering, and Mathematics, constitutes an educational method that pursues the interdisciplinary integration of these four disciplines in the teaching and learning process. Its purpose is to cultivate skills and competencies in 21st -century digital native students, enabling them to address real-world problems in a creative, critical, and collaborative manner (Silva-Díaz et al., 2023; Moral-Sánchez, Sánchez-Compaña, and Romero, 2022). To apply this methodology to the teaching of Natural Sciences, several key aspects must be considered, among which the importance of fostering interdisciplinary integration stands out (Colorado and Gutiérrez, 2018; Ortiz-Revilla, Aduriz-Bravo, and Greca, 2020; Neher and Wagner, 2022), seeking to connect Natural Sciences with other STEM disciplines. For example, when exploring a natural phenomenon, students may employ technology to collect data, apply mathematical principles for analysis, and consider engineering-based solutions. The absence of technological vocations, as well as the development of traditional teaching strategies, the lack of teacher training in STEM as an integrative approach, among others, are characteristic factors of educational systems worldwide (Jones, Geiger, Fallon , Fraser, Beswick, Holland & Hatisaru , 2024; Ayuso, Merayo , Rui, Fernandez , 2022; Li, Wang, Xiao et al, 2020).

The approach also advocates Project-Based Learning, proposing activities that present students with real-world challenges linked to the Natural Sciences. These challenges stimulate inquiry, problem-solving, and the application of scientific concepts in practical contexts. It is emphasized that secondary education under the STEM approach (Moral-Sánchez, Sánchez-Compaña, & Romero, 2022; Yaki, 2022) develops higher cognitive skills such as problem-solving and critical and creative thinking. This approach offers students the opportunity to conduct experiments, collect data, analyze results, and draw conclusions, thereby strengthening their understanding of scientific concepts, collaboration, problem-solving, and communication (Fairhurst , Koul , & Sheffield, 2023).

This approach also seeks to spark students' interest in science (Alom & Ranjan , 2024; Pozo,Lopez , Moreno, and Hinojo,2020) by connecting curricular content with everyday life situations and technological applications. The integration of projects and hands-on activities in the STEM Learning Environment contributes to improving the understanding of scientific concepts, while strengthening skills related to technology, complex problem- solving, critical thinking, and collaborative work, as part of 21st-century skills (Heredia & Herrera, 2025).

Therefore, the following question is addressed: What are the perceptions of students and teachers regarding the development of natural science competencies at the secondary education level using a STEM approach? What are the working conditions of students and teachers at the selected educational institutions in the Colombian Caribbean region for teaching natural sciences at the secondary education level?

2. METHOD

The epistemological approach underlying this research is positivist, with a quantitative research focus. The objective of quantitative research is to describe, verify, or identify all causal relationships between concepts derived from previous theoretical frameworks.

In this case, field research was conducted with high school students and natural science teachers from two public institutions in the Colombian Caribbean region. The present study population was high school students, consisting of 230 students in their final year of secondary school (grade 11). Thus, the purposive sample consisted of 128 students, who were willing to participate and provided their duly completed informed consent.

Surveys were administered to gather information on students' socioeconomic status and attitudes toward the Natural Sciences, as well as their interaction with technology. The survey consisted of two main sections. The first section, titled "Socioeconomic Characterization," collected basic demographic data, assessed the student's origin and length of residence in Colombia (if a student were a foreigner), explored the home environment, the availability of devices and technologies, parents' educational level, and the employment status and monthly income of household members. The second section, titled "Attitudes toward the Natural Sciences Subject," sought to assess students' attitudes toward these subjects, their willingness to participate in interactive and experimental activities, and their perceptions of the diversity and interest of Natural Sciences classes. It also examined their preferences regarding interactive teaching methods and teachers' use of technology.

Subsequently, a survey was administered to secondary school teachers in the area of natural sciences, with the objective of characterizing the conditions under which the different learning experiences are developed in the institutions where the research was conducted. This questionnaire consists of three parts. The first, "Validation of Physical Resources," evaluates the availability and conditions of laboratories, equipment, internet connection, and other technological resources in the educational institution. The second, "Validation of Pedagogical Strategies," explores the implementation of pedagogical strategies related to STEM, robotics, curricula, and Maker. Space , technical drawing, 3D printer, among others, and the third, seeks to find out if the institution has adopted specific strategies to strengthen the teaching of Natural Sciences under the STEM approach.

3. DISCUSSION OF RESULTS

As part of the results, Figure 1 shows that 51.6% of the students are male, while 48.4% are female. The age range of the students in the selected sample ranges from 12 to 19 years, with the majority of students aged 16 and 17 being 47.7% and 28.9%, respectively

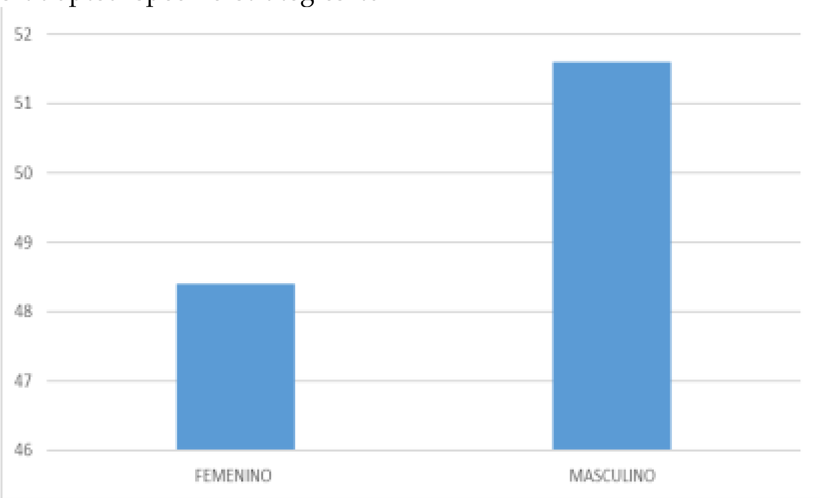

Figure 11*: Gender Of Students At The Educational Institutions Evaluated.*
Source: Own Elaboration (2024).

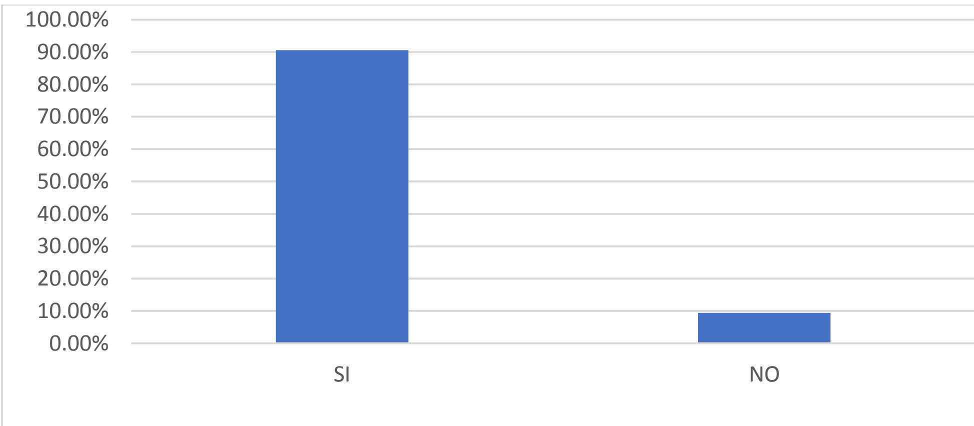

Figure 2: Knowledge and Use of Technological Devices.
Question: Does The Institution Use Technological Devices Such As Computers, Tablets, Laptops, Etc.?

The socioeconomic profile also shows that 90.6% of students are familiar with or have used technological devices such as tablets, laptops, PCs, among others. For various reasons, teachers bring them to the institution because they own them and use them, or they are available at the school's office. Meanwhile, 9.4% are unfamiliar with them, meaning they have not had the opportunity to use them. This situation is contrary and unusual among young people of the same age as students who belong to the digital native generation (Figure 3).

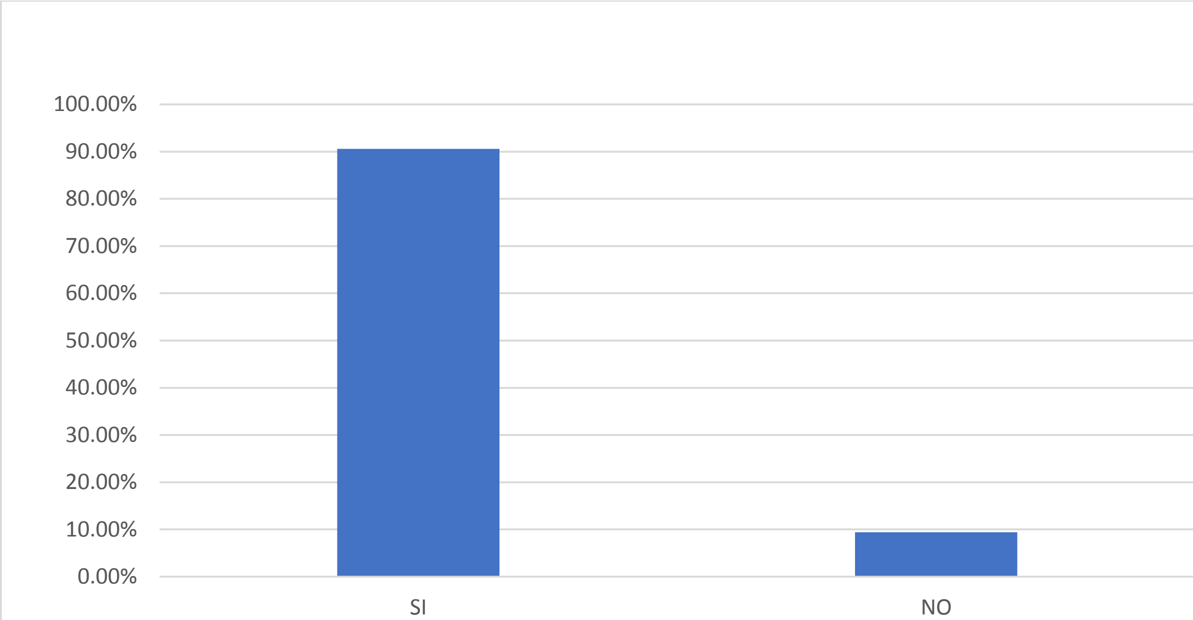

Figure 3: Question: Is The Institution Familiar With Technological Devices? (Computers, Tablets, Laptops, Etc.)

Regarding the question on Parents' Educational Level, Figure 4 shows that the majority of fathers and mothers, 47% and 41% respectively, completed their high school studies and 5% of both parents are professionals.

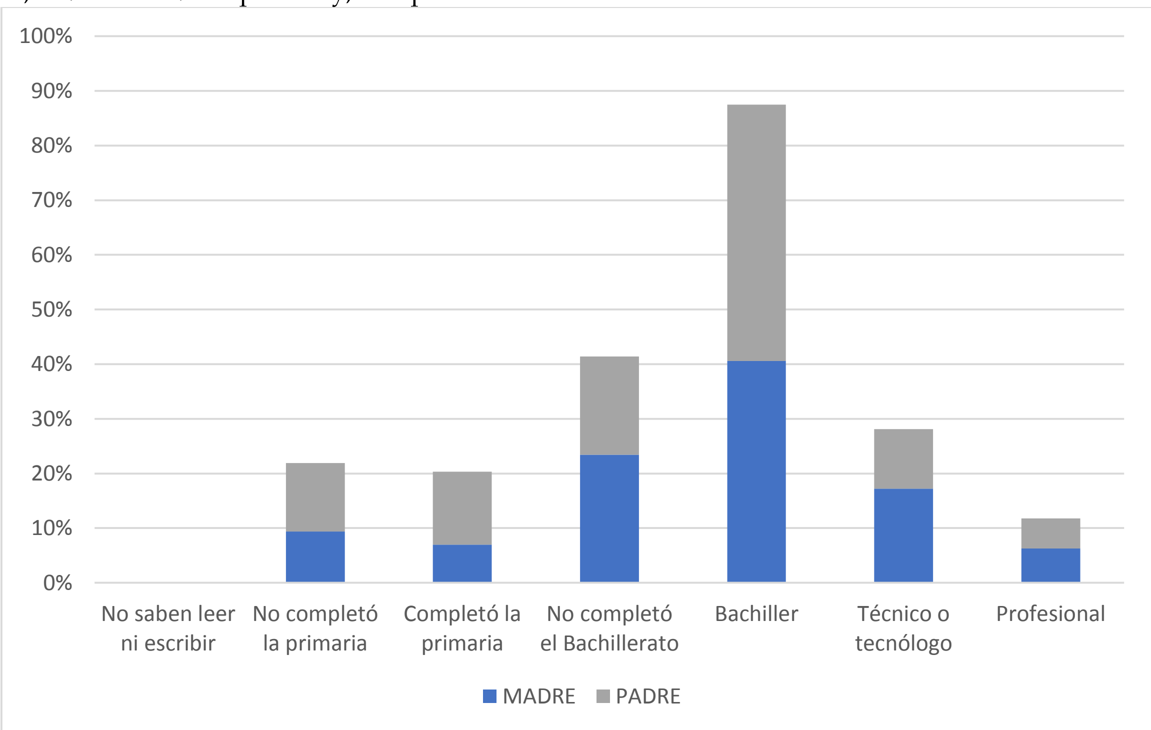

Figure 2: Question: Parents' Educational Level.
Source: Own Elaboration (2024).

Finally, the socioeconomic profile shows that only 18% of households receive incomes above the current legal monthly minimum wage. Thirty-five percent receive between $500,000 pesos and the current legal monthly minimum wage; 27% receive between $250,000 and $500,000 pesos per month; and 20% receive less than $250,000 pesos per month (Table 1).

Table 1: Percentage of Monthly Household Income.

Household income	Percentage of households
Less than 250,000 pesos per month	20%
Between 250,000 and 500,000 pesos per month	27%
Between 500,000 pesos and the current legal monthly minimum wage	35%
More than one current legal monthly minimum wage	18%

Source: Own Elaboration (2024).

Although most parents have completed high school, very few have a professional degree, which affects families' economic status and income, particularly the latter. Most families receive the current legal minimum monthly wage, which often makes it difficult to acquire school materials and resources such as books, technological devices (computers, tablets) , or internet access. Another very common situation in these contexts is that children must temporarily or permanently drop out of school to work and contribute to the family economy.

All of the above makes it difficult for parents to provide effective and efficient support at home to foster the acquisition of knowledge. This goes against what the authors have stated: the constant acquisition of knowledge is formed along the way, which is why we are always seeking to improve and strengthen our cognitive patterns through the application of various educational tools. One of the useful means in the 21st century is digital technology because it is available to everyone; for this reason, connectivist learning has become necessary in this new era of education (Velázquez Monroy BS, 2021). Furthermore, based on Siemens' educational theory in the digital age, technology allows individuals to immerse themselves in a continuous process of learning for themselves through experience in their daily lives (Siemens, 2010).

Below in Table 2, the responses to the questions in the section Attitudes towards the area of natural sciences are shown, perception given by 11th grade students. The results show a positive trend towards these attitudes, mainly in what corresponds to the acquisition of knowledge with 36.7% for Always and 24.2% Almost always, for the level Never it corresponds to 4.7% and the interest in learning the subjects that correspond to the area of natural sciences , with 27.3% Almost always, 24.2% Always and Sometimes 40.6%.

It is important to note that a small number of students agree that science classes are boring, with 3.1% saying "Never" and 5.5% saying "Almost Never." However, they perceive that the learning outcomes are not as expected, with 22.7% saying "Never" and 26.6% saying "Almost Never." It is important to note that the majority of students feel confident and secure in this area, with 29.7% saying "Almost Always" and 22.7% saying "Always."

Table 2: Responses To Questions About Attitudes Toward The Field Of Natural Sciences Expressed In Percentages.

Item	%Never	%Hardly ever	%Sometimes	%Almost always	%Always
1. I am interested in learning about natural science subjects.	23	5.5	40.6	27.3	24.2
2. I like to get involved in the field of inquiry and research.	4.7	11.7	42.2	22.7	19.5
3. Natural Science classes are fun and interesting	3.1	5.5	48.4	25.8	20.3
4. Assessments in natural science subjects are dynamic	5.5	10.9	45.3	27.3	12.5
5. I acquire more knowledge when science classes involve experiments, laboratories, or interactive activities.	4.7	7.8	28.1	24.2	36.7
6. I find natural science classes boring.	25	31.3	34.4	7.8	3.1
7. I feel like I'm doing badly in science classes.	22.7	26.6	43	7.8	3.1
8. During activities such as workshops, presentations, classroom activities, and assessments in natural science subjects, I feel stressed and/or anxious.	14.1	33.6	32.8	13.3	9.4

9. In science classes I feel confident and secure.	23	13.3	33.6	29.7	22.7
10. Teachers use technological means to help you better understand the topic covered in class.	3.9	14.1	41.1	28.9	13.3

Source: Own Elaboration (2024).

When analyzing the perceptions of students who responded individually to the questions provided regarding their attitude toward natural science classes, it is evident that a large portion of students show enjoyment and interest in learning during natural science classes. This is related to what (Santander, 2018) states when he states that nowadays students need to have a full willingness and desire to learn. To achieve this, it is necessary to build favorable learning environments that allow them to be motivated and aware of their training. If students are interested and willing to take classes in an area of knowledge such as natural sciences, they can adapt to the new way in which society communicates, stores, and learns in information and communication networks (Siemens, 2004).

In addition, a positive attitude toward inquiry based on a relevant question helps students draw on factual information, acquired knowledge, and the ability to create or imagine possible solution strategies to address the problem at hand. However, this is not reflected in the results obtained by students on external assessments.

Regarding the instrument applied to teachers on the spaces and conditions that both institutions have for teaching Natural Sciences (table 3).

Table 3: Percentage of Responses to the Questions Of The Instrument Applied To Teachers.

Items	% Yeah	%No
1. The institution has laboratories (physical space) for teaching natural sciences.	100	0.0
2. The physical space of the laboratories has the appropriate conditions for developing practical classes.	37.5	62.5
3. The laboratory(s) are equipped with the necessary materials for natural science classes.	2.5	87.5
4. The laboratory(s) have an internet connection.	12.5	87.5
5. The laboratory(s) have a computer.	12.5	87.5
6. The laboratory(s) have a multimedia projector, television or screens for projecting classes, videos, movies or other types of images.	25	75
7. For science classes, there is some software for virtual laboratories. If the answer is yes, please clarify which one in the comments.	12.5	87.5
8. Tablets or laptops are available for classes and laboratory activities in natural sciences.	12.5	87.5
9. Some strategy related to robotics has been implemented in the educational institution.	25	75
10. The natural science curricula are designed according to technology standards within the STEM education model.	12.5	87.5
11. The institution has a Maker Space that promotes creativity and the materialization of ideas.	12.5	87.5
12. The institution has a technical and/or artistic drawing laboratory.	25	75
13. The institution has a 3D printer.	12.5	87.5

Note. Prepared By The Authors (2024).

The results show that both institutions have laboratories for teaching natural sciences; however, 62.5% of the teachers surveyed stated that the physical space of the laboratories does not have adequate conditions for practical classes, and 87.5% stated that the laboratories are not equipped with the necessary materials and resources for natural science classes.

In addition, 87.5% stated that the laboratories do not have internet access or a computer, and 75% acknowledged that the laboratories also lack a multimedia projector or television for projecting lectures, videos, movies, or other audiovisual resources. Furthermore, 87.5% responded that there is no software for virtual labs for natural science classes, nor are there tablets for natural science classes and labs.

It is important to note that 75% of teachers believe that no robotics-related strategy has been implemented in the educational institutions where the study was conducted, while 87.5% believe that natural science curricula are not designed according to technology standards within the STEM education model. This same percentage states that the institutions do not have a Maker A space that strengthens creativity and the realization of ideas. Finally, the teacher survey determined that 75% of them believe their institution lacks a technical and/or artistic drawing lab, and 87.5% state that it also lacks a 3D printer.

It is important to highlight that the institutions have laboratories dedicated to teaching natural sciences, as revealed by 100% of the affirmative responses. However, a deeper look into the state of the laboratories reveals that 62.5% of teachers believe the physical space lacks adequate conditions for practical classes. This assessment suggests a significant concern that should be addressed to improve facilities and optimize the learning environment. Similarly, it is noted that most laboratories lack the necessary materials for natural science classes, according to 87.5% of the responses . This deficiency can represent a considerable obstacle to the effectiveness of practical classes, as resources are fundamental to a comprehensive education.

Internet connectivity in laboratories is also an area of concern, with 87.5% reporting a lack of connection, a very common situation in public educational institutions in the Colombian Caribbean. Given the importance of technology in education today, this lack of access limits the availability of online resources and educational tools. Similarly, the lack of computers in 87.5% of laboratories could negatively impact the integration of technology in science classes. Technology, when used appropriately, can enrich the educational experience and prepare students for the digital world (Ochoa, Canquiz & Lubo , 2022; Graca , Sole & Ramos, 2023).

The limited availability of audiovisual media, with only 25% of labs equipped with a multimedia projector or television, suggests a restriction on the projection of multimedia content during classes. This aspect could affect the variety of teaching resources available. Regarding virtual practices, the lack of software for virtual labs in 87.5% of classes indicates a limitation in digital learning opportunities. This highlights the need to incorporate virtual tools to enrich the educational experience (Pino, 2021).

tablet shortage in 87.5% of cases could affect the integration of technology in the classroom, as these devices can be valuable for interactive learning and mobility. On a positive note, 25% of institutions have implemented robotics-related strategies, which is encouraging for the development of STEM skills among students. However, the lack of alignment of curriculums with technology standards in 87.5% of cases suggests an opportunity for improvement to strengthen STEM education (Sánchez, Ramos, Linde, & Sanchez, 2023).

4. CONCLUSIONS

This study showed that, although both students and teachers show a positive attitude toward learning and teaching natural sciences through a STEM approach, there are structural barriers that significantly limit its effective implementation. These include students' socioeconomic conditions, limited technological availability in homes and educational institutions, and insufficient pedagogical and physical resources, such as equipped laboratories and connectivity.

Despite these limitations, students express a strong interest in scientific inquiry and interactive methodologies, which constitutes a favorable starting point for fostering innovative pedagogical practices. For their part, teachers recognize the need to update curricular infrastructure and strategies to respond to the demands of the STEM approach and the development of 21st-century skills.

The above analysis shows the lack of necessary elements to develop appropriate learning environments and improve student performance and skills in the area of natural sciences at both educational institutions. Although the physical space exists for practical activities in natural sciences, technological tools, appropriate science laboratory materials, and internet access are lacking.

The lack of a Maker Space limits opportunities for the development of creative skills and problem-solving, highlighting another area for potential improvement. The lack of equipment for technical and/or artistic drawing labs for the development of artistic and technical skills is also lacking. Similarly, the lack of 3D printers, which facilitate the printing of three-dimensional ideas, highlights another area for improvement.

In this sense, these deficiencies can affect the quality of learning and teaching processes in the natural sciences and other areas. The results offer specific areas for improvement and updating in the educational infrastructure, with the goal of optimizing the learning environment and providing a more enriching educational experience. In this regard, it is proposed to organize the different learning experiences through a STEM approach, which gives students the opportunity to conduct experiments, collect data, analyze results, and draw conclusions, thus strengthening their understanding of scientific concepts. Similarly, contextualization stands out as a component when relating scientific concepts to real-world situations. This approach helps students understand the relevance of what they learn and how it applies to their everyday environments.

Under the STEM approach, students can explore scientific concepts in a practical and applied way, promoting critical skills such as analytical thinking, problem-solving, and creativity. Thus, students' interest in science is sparked by connecting curricular content with everyday situations and technological applications, contributing to a better understanding of scientific concepts while strengthening technology-related and problem-solving skills. This opens the way for new research addressing the implementation of the STEM approach in teaching specific cognitive areas in education at all levels.

Data Availability Statement: The data supporting the findings of this study are available from the corresponding author, upon reasonable request.

Ethics Statement: Ethical approval was not required for the study involving humans in accordance with the local legislation and institutional requirements. Written informed consent to participate in this study was not required from the participants or the participants' legal guardians/next of kin in accordance with the national legislation and the institutional requirements.

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