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ORIGINAL ARTICLE

The teaching and learning of mathematics in high school and its relationship with affectivity

Ensino-aprendizagem de matemática no ensino médio e sua relação com a afetividade

La enseñanza-aprendizaje de las matemática en la escuela secundaria y su relación con la afectividad

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ABSTRACT

Understanding student emotions, beliefs, and attitudes is essential for developing teaching-learning strategies that improve engagement and academic performance, particularly concerning mathematics, a subject in which many students have trouble. Thus, this article aims to expose the understanding of affectivity in relationships involving the teaching and learning of mathematics to Integrated High School (EM - High School) students at the Federal Institute of Alagoas. The exploratory study involved bibliographical research and a data collection phase where information was collected about beliefs, attitudes, and emotions related to student affectivity and its impact on learning. The responses were analyzed using the Likert scale. A greater influence of affectivity, specifically on mathematical learning, was recorded in students in the 1st year of EM compared to those in the 2nd and 3rd year. This way, the present study provides support to improve the training of educators and

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register evidence about the importance of affectivity in the educational context, supporting public policies and pedagogical practices aligned to the emotional needs of students.

KEYWORD: affectivity; teaching-learning; mathematics; high school.

RESUMO

Compreender emoções, crenças e atitudes discentes é essencial para o desenvolvimento de estratégias de ensino-aprendizagem que melhorem o engajamento e o desempenho acadêmico, particularmente no que diz respeito à matemática, disciplina em que muitos estudantes sentem dificuldade. Assim, este artigo objetiva expor a compreensão sobre a afetividade nas relações que envolvem ensino-aprendizagem de matemática em alunos do Ensino Médio Integrado (EM) do Instituto Federal de Alagoas. O estudo exploratório envolveu uma pesquisa bibliográfica e uma etapa de levantamento de dados, na qual foram coletadas informações sobre crenças, atitudes e emoções relacionadas à afetividade discente e seu impacto na aprendizagem. As respostas foram analisadas através da escala de Likert. Uma maior influência de afetividade, especificamente, na aprendizagem matemática, foi registrada nos alunos pertencentes ao 1º ano do EM quando comparado aos dos 2º e 3º anos. Desta forma, o presente estudo fornece subsídios para aprimorar a formação de educadores e registrar evidências sobre a importância da afetividade no contexto educacional, embasado em políticas públicas e práticas pedagógicas alinhadas às necessidades emocionais dos estudantes.

PALAVRA-CHAVE: afetividade; ensino-aprendizagem; matemática; ensino médio.

RESUMEN

Comprender las emociones, creencias y actitudes de los estudiantes es esencial para desarrollar estrategias de enseñanza-aprendizaje que mejoren el compromiso y el rendimiento académico, particular con respecto a las matemáticas, una materia en la que muchos estudiantes experimentan dificultades. Así, este artículo tiene como objetivo exponen la comprensión de la afectividad en las relaciones que involucran la enseñanza-aprendizaje de las matemáticas, en estudiantes de la Escuela Secundaria Integrada (EM), del Instituto Federal de Alagoas. El estudio exploratorio implicó una investigación bibliográfica y una etapa de recolección de datos, donde se recopiló información sobre creencias, actitudes y emociones, relacionados con la afectividad de los estudiantes y su im-

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pacto en el aprendizaje. Las respuestas se analizaron utilizando the Likert scale. Se registró una mayor influencia de la afectividad en el aprendizaje matemática en los estudiantes pertenecientes al 1º año de EM, en relación con los de 2º y 3º años. Así, el presente estudio brinda apoyo para mejorar la formación de los educadores y registrar evidencia sobre la importancia de la afectividad en el contexto educativo, sustentando políticas públicas y prácticas pedagógicas alineadas con las necesidades emocionales de los estudiantes.

PALABRAS-CLAVE: afectividad; enseñanza-aprendizaje; mathematicians; escuela secundaria.

1 Introduction

When considering the affective dimension as an essential component that needs to participate in the teaching-learning processes of mathematical contents, it can be seen that, in a classroom, we are faced with totally different individuals, with varying kinds of family relationships, personal and socioeconomic problems, and facing difficulties in believing in themselves. According to Chacón (2005), emotions play a significant role in how students approach and deal with mathematical concepts.

Accordingly, Cazorla *et al.* (2008) states that the affective dimension can play a significant role in students' academic performance in mathematics. If students have a negative attitude toward the subject, low level of motivation, or anxiety about math challenges, it may affect their ability to learn and apply math concepts. On the other hand, when students have a positive perception of mathematics and feel motivated and confident in their skills, affective mastery can become a driver of academic success, improving their ability to face challenges and persist in the face of difficulties and seek more involvement with learning the subject.

Cazorla *et al.* (2008) divides the affective domain into three categories: beliefs, attitudes and emotions. Beliefs are one of the components of the

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individual's implicit subjective knowledge about mathematics, its teaching and learning, based on the individual's experience. They can be classified as beliefs about: mathematics; oneself; teaching of mathematics, and the social context in which one grows up. Attitudes, on the other hand, are configured as an evaluative predisposition (positive or negative) that determines personal intentions, formed by a cognitive, affective, or intentional component and an influence behavior. Finally, emotions

> Constitute organized responses beyond the boundary of psychological systems, including the physiological, cognitive, motivational, and experiential systems, and arise in response to an event, internal or external, that has a positive or negative charge on the individual (Cazorla *et al.*, 2008, p. 149).

By investigating the relationship between affectivity and the learning process in mathematics, these researchers provide a better understanding of the mechanisms involved in constructing knowledge in this subject and the emotional experiences of students when facing mathematical challenges. These studies allow the identification of factors that facilitate or hinder mathematical learning, contributing to developing more effective and inclusive pedagogical strategies. Understanding how emotions and affective aspects can positively or negatively influence students' engagement with mathematics is critical to creating a more welcoming, encouraging, and motivating learning environment.

In view of this, to show that affectivity can affect human beings and, in particular, their school performance, we rely on the studies of Wallon (1971), who innovated, by placing affectivity as one of the central aspects of development. This author defended that the process of evolution, in cognitive terms, depends both on the biological capacity of the subject and on the environment, which affects it in some way. For example, it can be seen that when students enter the first year of high school at the Federal Institute of Alagoas (IFAL), Maceió *Campus*, they undergo a sudden change in their school reality, such as the

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presence of integrated education and a new school structure. However, in the process, young people are adapting and facing new challenges. In addition, during this period, students face preparatory entrance examinations and decisions about their academic, personal and professional future. Finally, with the huge number of subjects per year, the relationship with the subject of mathematics becomes much more complex in relation to that studied in Elementary School.

Mathematics is one of the subjects most loaded with negative emotions by students (Alves; Dantas; Oliveira, 2012). Thus, for this conception to be reduced to a minimum proportion, it is essential that the affective dimension be inserted in the school context. Therefore, this research sought to answer the following question: "*How can affectivity contribute/hinder the mathematics teaching-learning process of students regularly enrolled in IFAL High School – Maceió Campus?*". To answer this, we aim to understand the role of affectivity in the mathematical teaching-learning process, the patterns in the categories analyzed, the subsidies for educational practice, and how the influence of affectivity can vary throughout the students' academic journey.

2 Methodology

According to Lüdke and André (1986), the role of the researcher is fundamental to the trajectory of research since it is characterized by a constant movement for the sake of knowledge construction. In addition, the acquisition of this knowledge may contribute to important transformations in the ways in which the subject interacts with reality. Thus, this study adopted an exploratory character that, according to Gil (2017, p. 32), "aims to provide greater familiarity with the problem, with a view to making it more explicit [...]". In addition, it followed a quali-quantitative approach, collecting and analyzing

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data or findings to draw inferences from a single investigation (Tashakkori; Creswell, 2007) and conducting bibliographic research for a theoretical basis.

Therefore, we conducted a systematic review seeking the answer to the question: "What is being studied about the relationship between affectivity and the teaching-learning process of mathematics?". For this, we followed the stages guided by Wohlin *et al.* (2012): planning the review, conducting the review, and reporting the results. In the planning of the review, the authors indicate the actions of identification of the need to make a review, the specification of the research question (where both actions were presented in the introduction of this work), and the development of a review protocol that aims to define the procedures for carrying out the systematic review.

Four research repositories were chosen for this review: *Google* Scholar, SciELO, *Scopus*, and Capes Journals. For the search *string*, we tried to use a more comprehensive one that could give us as many searches as possible. Therefore, we use the *string* ("*math*" OR "*mathematics*") AND ("*emotional*" OR "*affectivity*") in an attempt to obtain all works in which there are, throughout the text, these terms. Still, within the review planning, some inclusion (IC) and exclusion (CE) criteria were chosen *a priori*, namely: (CI1) Analyzes affectivity from the student's point of view; (CI2) Alignment with the research methodology; (CE1) Does not analyze the relationship between affectivity and teaching-learning; (CE2) Does not present a summary.

All this information was entered into the *Parsifal* platform, where we can manage both the planning and the next stage of the research. The searches were conducted between October 16 and 21, 2022, in the chosen repositories, and 201 papers were found. Then, using the duplicate identification tool, we limited the search to 200 papers.

After this first refinement, the authors of this research were responsible for selecting, based on the titles and abstracts of the papers, which would be

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included, excluded or read (and may be included or excluded later). In Table 1, we can see how many papers were found in each research repository, as well as how many were included and how many were excluded.

TABLE 1 - Manuscripts found in each repository.

Database	Included	Deleted	Total
Google Scholar	0	90	90
Capes Journals	15	80	95
Scielo	1	7	8
Scopus	0	7	7
Total	16	184	200

Source: the authors (2023).

As for affectivity in mathematical learning, the theory of Chacón (2000) was used, which defines the affective domain as attitudes, beliefs, evaluations, likes and dislikes, emotions, feelings, and values. Analogous to the studies by Chacón (2000), the definitions made by Cazorla *et al.* (2008) were used for the construction of the questionnaire. These definitions bring the concepts of terms that are part of the affective domain: beliefs are one of the components of the individual's implicit subjective knowledge; attitudes are configured as an evaluative predisposition (positive or negative) that determines personal intentions and influences behavior. Emotions arise as a response to an event, internal or external, that has a positive or negative charge for the individual.

After that, a survey was made of how many students were regularly enrolled in the Integrated High School of the Federal Institute of Alagoas, with a total of 1560 on July 30, 2023, according to the School Census available on the Nilo Peçanha Platform (PNP) (Brasil, 2023).

Concerning the research participants, after surveying the number of students regularly enrolled in that educational institution, we calculated the number of students participating in the research, that is, the sample size, which represents

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only part of the group (or target population) whose opinions or behaviors are relevant to the research. To this end, three items were established:

a) population size (*N*): the total number of people in the group to be studied;

b) the margin of error (*e*): the percentage that indicates the level of correspondence of the survey results with the opinions of the total population. The smaller the margin of error, the more likely you are to have the exact answer at a specific confidence level;

c) sample confidence level (*z*): Percentage of confidence level that the population would select a response within a specific range. The z-score is the number of standard deviations between a given proportion and the mean.

Therefore, we use the formula to calculate the sample size:

$$Sample\ size = \frac{\frac{z^2 \cdot p(1-p)}{e^2}}{1 + \left(\frac{z^2 \cdot p(1-p)}{e^2 \cdot N}\right)}$$

Through the formula, the result for the sample size using 1,560 for the population size, 4% margin of error, and 90% confidence level of the sample resulted in 335 students being interviewed. After this survey, the *link* was sent to the classes, and with the help of the representatives and teachers, the previously calculated sample was reached.

In the third moment of the research, based on the studies carried out in the systematic literature review, as proposed by Kitchenham and Charters (2007), the construction of the questionnaire began (Table 2). For this, the Likert scale was used (Likert, 1932). It is commonly used in opinion surveys, in particular, those of a psychometric nature. When answering a questionnaire based on

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this scale, respondents specify their level of agreement with a statement, as follows: a) Totally disagree - indicates a good affective relationship with the discipline; b) Partially disagree; c) Indifferent; d) Partially agree and; e) Totally agree - indicates a poor affective relationship with the discipline. Each item was replaced with values from 1 to 5 in the response evaluation phase. At the end, each student had their grade.

Based on these studies, a questionnaire (Chart 1) was developed, built on the Google Forms platform, with 20 statements, divided into the following sections: belief in relation to mathematics; belief about oneself; belief in regard to the teaching of mathematics and the social context of the school and attitudes towards mathematics and emotions.

CHART 1 - Questionnaire applied to integrated high school students, with the objective of evaluating affectivity in mathematical learning.

Statements	
Beliefs	Belief in mathematics 1. Mathematics are concepts and procedures that we have to memorize. 2. Mathematics is too abstract for me 3. I have difficulty in understanding mathematics 4. I do not believe that what I learn in mathematics has application in everyday life
	Belief in yourself 5. I always think the subject will be difficult to understand 6. I get scared when I'm asked to solve math problems. 7. I feel negative feelings when I hear about math. 8. I believe I will not be able to learn mathematics
	Belief in the teaching of mathematics and the social context of the school 9. My math teachers never managed to get me to like the subject 10. I don't like to actively participate in math classes 11. My relationship with math teachers was distant 12. My math teachers made fun of me when I did something wrong in class
Attitudes	13. I give up easily when the problem is difficult. 14. I complain when there is math class on the day 15. I do not take the opportunity to enjoy the subject 16. As I consider it difficult, I do not do the activities proposed to me
Emotions	17. I feel anxious on a math test day 18. I've already cried because I got a low grade in math 19. I get sad when I can't solve a math problem 20. I feel frustrated in math classes

Source: the authors (2023).

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The data analysis of the questionnaires was based on the values answered by the students, in each of the categories mentioned, evaluating the general data by years (1st, 2nd, and 3rd year) of Integrated High School. It should be noted that the students were informed, in the form itself, that answering it was a voluntary and anonymous attitude, and no personal identification was collected, except only their objective response to it, for scientific dissemination.

The following is an excerpt from the discussions anchored in Chacón (2000; 2005) and Cazorla *et al.* (2008). It should be noted that the analysis was made considering the situations in which the participants were inserted; that is, a decontextualized analysis was not carried out, nor was it intended to draw an inflexible profile.

3 Results and Discussion

Affectivity plays an essential role in the learning process, and its impact on the study of mathematics is no exception (Cazorla *et al.*, 2008). Through the Likert scale (1932) application, the students' beliefs, attitudes, and emotions about the subject were investigated, seeking to understand how these aspects affect mathematical learning. Analyzing the data from the perspective of the influence of affectivity on the study of mathematics, it was possible to make some inferences and abstractions, both didactic and mathematical.

By observing the data mathematically, one can notice some significant trends. The category "totally agree - a bad affective relationship with the discipline" stands out in all three perspectives analyzed: beliefs (30%), attitudes (25%), and emotions (43%) (Table 2, Figure 1).

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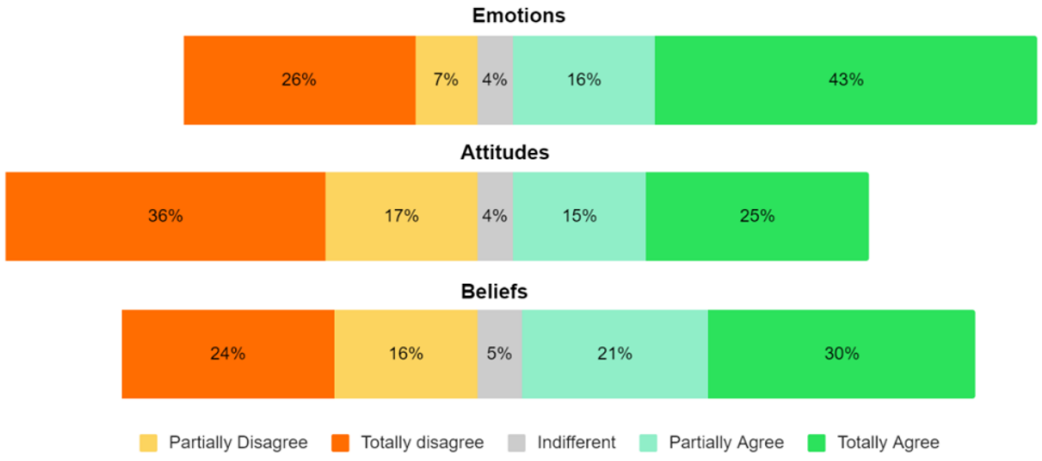
TABLE 2 - Percentage of responses obtained, by category investigated, among integrated high school students concerning affectivity in mathematical learning.

Category	Totally Agree	Partially Agree	Indifferent	Partially Disagree	Totally disagree
Beliefs	30%	21%	5%	16%	24%
Attitudes	25%	15%	4%	17%	36%
Emotions	43%	16%	4%	7%	26%

Source: the authors (2023).

FIGURE 1 - Likert Scale of the data recorded on affectivity in mathematical learning among integrated high school students from the Federal Institute of Alagoas.



Source: the authors (2023).

The data showed, as recommended by Chacón (2005), that many students have negative beliefs about mathematics, such as the idea that it is a complicated subject and of little practical use. In addition, many students demonstrate unfavorable attitudes, such as disinterest and resistance to learning mathematics.

Negative emotions such as anxiety and aversion are also prevalent, affecting how students deal with mathematical challenges. These data raise important questions about the pedagogical approach used in the teaching of mathematics. Educators need to be aware of the influence of affection on student learning. Often, the excessive focus on memorizing concepts and the lack of

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contextualization of mathematics in students' daily lives can contribute to developing negative beliefs about the subject.

A didactic analysis points to the need to carefully approach affectivity in the teaching of mathematics. Contextualizing learning by showing students how mathematical concepts are applicable in real life can help overcome negative beliefs and make the study of the subject more relevant and exciting. In addition, it is essential to value the students' effort, recognizing their achievements, even if they are small. This contributes to building self-confidence and motivation to face mathematical challenges. A supportive and welcoming environment is also critical for students to feel safe expressing their difficulties and fears regarding mathematics. Educators should be open to listening and offering emotional support to students, showing themselves available to assist them in their learning journeys. An active approach to teaching mathematics is also recommended, encouraging student participation in hands-on activities, group problem solving, and discussions. This can help engage students and make learning more meaningful by stimulating critical thinking and collaboration among students.

Considering the fundamental importance of affectivity in the teaching-learning process, especially in the discipline of mathematics (Cazorla *et al.*, 2008), the analysis of data on students' beliefs, attitudes, and emotions concerning mathematics allows us to better understand this affective influence and how it can vary throughout the educational journey. Figure 2 shows the results obtained in each year by category.

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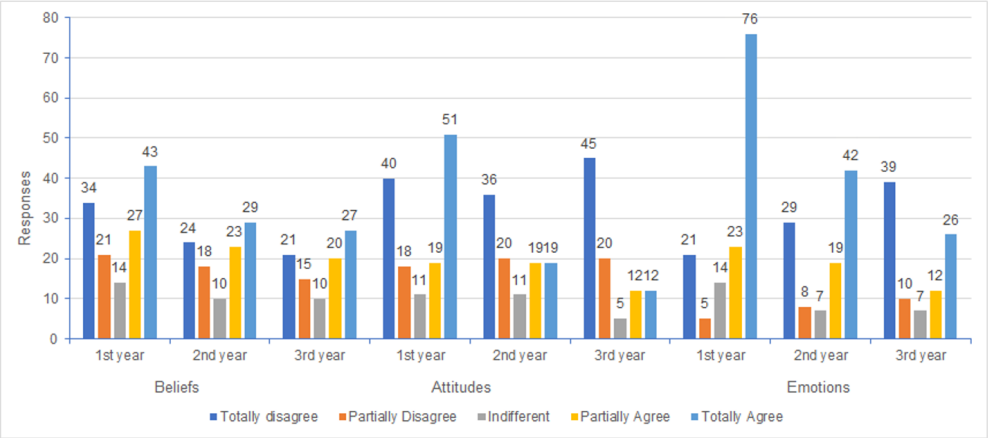
FIGURE 2 - Responses recorded in relation to affectivity in mathematical learning, in each year of high school, by category (beliefs, attitudes and emotions).



Source: the authors (2023).

By examining the categories analyzed in the three years, it is possible to identify significant patterns that reveal the affective relationship of students with mathematics, which is in accordance with Cazorla *et al.* (2008). The presence of a considerable number of students in the "strongly agree" category in beliefs, attitudes and emotions indicates that many students have a poor affective relationship with the subject. They fully agree that they have negative beliefs, unfavorable attitudes and negative emotions towards Mathematics. This situation can affect their engagement, motivation, and academic performance.

On the other hand, the "strongly disagree" category reveals a good affective relationship with mathematics. In this case, students fully agree that they have positive beliefs, favorable attitudes, and positive emotions towards the discipline, confirming the theoretical precepts of Chacón (2005). This is a relevant finding, as it demonstrates that some students have a positive emotional connection with mathematics, which can motivate their learning and academic growth.

Thus, given the greater influence of affectivity on mathematical learning recorded in students belonging to the 1st year of the high school when compared

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to students of the 2nd and 3rd years (Figure 2), some hypotheses are raised for this result, such as the transition of mathematics from the elementary school to the high school, since in the latter the former is used as support for learning new content; also, it can be related to the application of mathematics in technical subjects, which they have contact right in the first year.

On the other hand, in a decreasing way, in the 2nd and 3rd years, the values were lower, possibly indicating an adaptation to the relation of the mathematics of the elementary school to that of the high school, and/or technical education system and/or to the network of social relations acquired throughout the course.

Thus, the results corroborate with Chacón (2005) and Cazorla *et al.* (2008), for whom affectivity plays a significant role in the student's relationship with mathematics. Many students have negative beliefs, attitudes, and emotions about the discipline, which can negatively impact their engagement, motivation, and academic performance. On the other hand, some students demonstrated a good affective relationship with mathematics, totally disagreeing that they have negative beliefs, attitudes and emotions regarding the subject.

These findings point to the importance of considering the affective dimension in mathematics teaching. Contextualizing learning by making it more relevant to students' daily lives can contribute to overcoming negative beliefs and to arousing interest and motivation in the study of the subject. In addition, valuing the effort of students, creating a welcoming and stimulating environment and adopting an active approach in mathematics teaching can favor a more positive and healthy relationship with the subject.

These patterns (Figure 2) can also provide valuable subsidies for educational practice. It is essential that educators recognize the influence of affection on student learning and adopt pedagogical approaches that consider this emotional dimension. Creating a welcoming, stimulating, and motivating

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learning environment can help transform students' affective relationship with mathematics. Strategies such as using playful activities, solving real problems related to students' daily lives, and encouraging active participation can increase interest and motivation for studying mathematics.

Thus, considering what the data suggest, it is important to understand that the influence of affectivity can vary throughout the students' educational journey. In this sense, educators must be attentive to the emotional and academic development of each student individually. Individualized monitoring can identify specific needs, challenges and opportunities for improvement, favoring the construction of a more positive and healthy relationship with Mathematics throughout its school trajectory.

In short, the analysis of data on beliefs, attitudes and emotions in relation to mathematics offers a deeper view of the influence of affectivity on the teaching-learning process (Chacón, 2000, 2005; Cazorla *et al.*, 2008). Understanding these patterns and variations is essential to support a more effective educational practice tailored to students' individual needs. By valuing the affective dimension in the classroom and promoting a more positive relationship with mathematics, educators can significantly contribute to student's academic and emotional growth throughout their educational journey.

4 Final considerations

This research investigated the influence of affectivity on the mathematics teaching-learning process of students regularly enrolled in IFAL High School – Maceió *Campus*. Through the application of a questionnaire based on the Likert scale, the students' beliefs, attitudes and emotions in relation to the subject were analyzed, seeking to understand how these aspects affect mathematical learning.

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From the results obtained, it is concluded that affectivity plays a central role in the teaching-learning process of mathematics. Understanding students' emotional aspects and considering the affective dimension in educational practice can significantly contribute to students' academic and emotional growth. In this sense, educators need to be aware of the importance of creating a welcoming, stimulating and motivating learning environment, promoting a positive and healthy relationship between students and mathematics.

The analysis also showed that the influence of affectivity can vary throughout the students' educational journey, acting more significantly in students in the 1st year of high school. Thus, it is essential that educators are attentive to the emotional and academic development of each student individually, providing personalized follow-up tailored to the specific needs of each one.

As limitations of this study, the sample size stands out, which may not represent all students enrolled in IFAL High School – Maceio *Campus*. In addition, the quali-quantitative approach may limit the depth of analysis.

Thus, future investigations related to pedagogical strategies that promote a more positive and healthy relationship between students and mathematics are suggested. In addition, it is relevant to study how the affective dimension can influence the learning of specific mathematical concepts and how it relates to other factors, such as students' overall academic performance.

In short, studies that seek to understand how affectivity can contribute or hinder the mathematics teaching-learning process are fundamental for the improvement of educational practice and for the promotion of a more welcoming, encouraging and motivating learning environment for students. By valuing the affective dimension, educators can enhance students' academic and emotional development, preparing them to face the challenges of mathematics and life with greater confidence and quality.

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Our gratitude also expands to the students and teachers who kindly participated in this research, sharing their perceptions, experiences and emotions regarding the teaching-learning of Mathematics. Their contributions were fundamental to the basis of the results presented.

Finally, we want to acknowledge the importance of science and academic research as engines of human progress. Through this opportunity provided by FAPEAL and the tireless support of our advisor and collaborator, we were able to advance the understanding of affectivity in mathematics education, and we hope that our findings can inspire future investigations and promote more effective and inclusive educational practices.

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