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Attitudes Toward Mathematics Of Prospective Teachers In Border Educational Contexts

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Abstract

This educational research was developed in a group of future mathematics teachers from two public educational institutions in Colombia, with very similar geographical and social conditions. The results reported are part of a broader investigation in which the perceptions of a non-probabilistic sample of 212 students about the basic descriptors of the affective domain towards mathematics were explored. The findings allow verifying that attitudes are a social construction that originates from experiences and interactions with other people. Likewise, it was possible to identify that there were many coincidences in both groups of students regarding their attitudes towards mathematics, but it was possible to identify in both groups of informants, that there was a percentage of no more than 5% of the people who entered this teacher training program, but without having a teaching vocation or a taste for the discipline, which is why they do not hide their negative attitudes.

Keywords: Affective Domain towards Mathematics$_1$, Future Teachers$_2$, Higher Education$_3$, Education$_4$, Attitudes$_5$.

1 Introduction

Education is a fundamental process for the development of a country since it contributes to the qualification of citizens from a holistic vision both as sociable human beings and as productive people within an economic system (Aguilar, 2018).

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But for this objective to be fulfilled, coherence is necessary between the formative process that is advanced in educational institutions and the competencies of the professionals demanded by society, that is, a quality process must be offered. Regarding the quality of education and its contributions to the development of a country, Díaz and Tobar (2016) state that "educational quality is a topic that has been widely studied in the field of the economics of education because it promotes social mobility, economic growth, poverty reduction and social welfare" (p. 1).

In this sense, the document proposed by Vasco (2006) highlighted the main challenges to be faced by Colombian education in the next 25 years. The author mentions investment in education is the most profitable field for the country; to articulate quality with coverage to reduce the high rates of educational desertion; to make the transition from teaching and evaluation by achievements to competencies, which mainly requires a change in the evaluation practices applied by the Colombian Institute for the Promotion of Higher Education (ICFES), since the results of the SABER tests are the criterion to determine the quality of the educational process of an institution and, based on them, improvement plans are designed. The quality of the educational service must be guaranteed regardless of the socioeconomic characteristics of the context in which the institution is located. The teaching of civic education and religion (respecting pluralisms) as values within society must be retaken. The coherent articulation of the various levels of education; and finally, the quality standards in specific subjects of the school curriculum such as natural sciences, mathematics and technologies must be improved while working on the transformation of the rejection that students show in the subjects of mathematics and natural sciences.

Regarding the study and possible rejection of the academic community towards mathematics and the natural sciences, Vasco (2006) reports

> the disdain for the pedagogy and didactics of mathematics and natural sciences among professionals in these areas, even in their undergraduate studies, and even more so in those who have postgraduate degrees, from the demographic point of view by boring, humiliating and banishing from mathematical paradise and scientific paradises young people who do not achieve good results in their areas. This is reducing the number of aspirants to advanced studies in these areas and preventing the expansion of citizen support and for those who want to study these areas (p. 36).

The above shows the existence of difficulties in the processes of teaching, learning and evaluating both natural sciences and mathematics. This paper will focus on mathematics as specific knowledge.

For example, the results of Colombian students in international tests such as TIMSS (Trends in International Mathematics and Science Study) or PISA (Program for International Student Assessment) in mathematics between 1995 and 2007 have been low in comparison with the other participating countries, placing them in the last places (Díaz and Tobar, 2016). This panorama does not change much when analyzing the results of internal tests, such as the SABER tests, where, for example, between 2002 and 2012, students at the basic education level showed a slight improvement, in contrast to those in secondary education, who improved in the same time, but highlighting that more than 60% of the scores are below the average of the scale used (Díaz and Tobar, 2016).

The aforementioned results show the importance of assessment within the educational process, since, as López (2013) states, "the assessment of learning is a fundamental aspect ..., since the results are used to obtain important information about what students know, and to make important decisions that will affect their lives"

(p. 1); then it is required that the assessments applied to students are valid, that is, that they measure what they are expected to measure and in coherence with what is taught in the classroom.

Then, when approaching the edge associated with the processes of teaching and learning mathematics, but from the point of view of the factors that are influencing the achievement of adequate academic performance, Table 1 shows, without being exhaustive, some studies developed to identify factors that influence mathematics performance. Through Table 1 and without being exhaustive, some studies developed for identifying those factors that influence mathematics achievement are mentioned.

Table 1 Research reporting the influential factors on academic achievement in Mathematics.

Researchers	Characteristic appearance
Gómez-Chacón (1998)	Aimed to determine and describe how cognitive and affective factors interact with the learning of mathematics in students who had lost the subject within a context of social exclusion.
Miñano et al. (2012)	Evaluated the degree of influence and interaction of motivation together with intelligence and learning techniques as predictors of school performance.
Cerda et al. (2017).	Sought to quantify the incidence that predisposition towards mathematics can have within a model in which some cognitive abilities such as formal logical reasoning and the levels of logical intelligence of the inductive type exhibited by the students on academic performance in mathematics were considered.
Chaves et al. (2008)	Describe the influence of students' beliefs about mathematics and its teaching on academic performance.
Gil et al. (2005)	The research shows that affective issues play a predominant role in the processes of teaching and learning mathematics and that some of them are deeply rooted in the subject and are not easily displaced by instruction. They addressed the main basic descriptors of the affective domain, beliefs, attitudes and emotions, and how feelings will condition the student's success and/or failure when facing this discipline.
Fernandez et al. (2018).	The importance of the affective domain and the pedagogical practices promoted by mathematics teachers in their classroom work is highlighted.
Alsina and Coronata (2015).	Present the process of design, construction and validation of an instrument to evaluate the presence of mathematical processes in mathematics teaching-learning practices.
Bastién et al. (2010)	Inquired about the obstacles experienced by underachieving students

	when solving problems.
George (2020)	Aimed to analyze the impact of the use of technologies with the purpose of reducing obstacles, especially those related to the prevalence of erroneous conceptual and procedural knowledge at the baccalaureate level of education.

From the information shown in Table 1, the complexity of the subject is highlighted given the wide diversity of factors that are possibly affecting success or failure in mathematics. In this sense, García (2012) assures that "learning processes are extremely complex processes since they are the result of multiple causes that are articulated in a single product. However, these causes are fundamental of two orders: cognitive and emotional" (p. 97). Refining, even more, the object of this research, the study will focus on those emotional factors.

In a broad sense, the expression affective domain in mathematics is used, highlighting what is stated by McLeod (cited in Gil et al., 2005) as "an extensive range of feelings and moods (states of mind) that are generally considered as something different from pure cognition and includes as specific components of this domain attitudes, beliefs, and emotions" (p. 50). In this sense, Gil et al. (2005) emphasize that "for a long time, studies on the affective dimension in mathematics were limited to the study of attitudes" (p. 49).

Regarding mathematical beliefs, it can be stated that "they are the personal thoughts one has about the discipline, its teaching and learning that are created by the individual through experience" (Duarte et al., 2018). In McLeod (1992), four categories are recognized about beliefs: a) beliefs about mathematics and its teaching and learning processes; b) beliefs about oneself as a learner of mathematics; c) beliefs about the teaching of mathematics; and d) beliefs elicited by the social context (cited in Gil et al., 2005, p. 18).

On the other hand, emotions are a set of observable feelings in people through their physiological reactions such as altered breathing, sweating or reddening of the face (Martínez, 2005, cited in Duarte et al., 2018; Amaya-Mancilla et al., 2020). These emotions produce reactions that directly affect the learning process of mathematics, given that, if they experience anger or fear, it hinders in the student their willingness and ability to understand.

Finally, attitudes could be considered as "positive or negative feelings about an object or situations which will condition their thinking and way of acting" (Duarte et al., 2018, p. 64). Gairín (1990, cited in Martínez, 2005), assures that "attitudes are instances that predispose and direct the subject on facts of reality, filter perceptions and guide thinking to adapt it to the context" (p. 18).

Paraphrasing Martínez (2005), who in turn relied on the proposals of several authors, defines the main characteristics of attitudes: a) they are learned by the individual from his lived experiences; b) they are maintained over time unless they are acted upon for their transformation; c) they are associated with events, occurrences or people individually or in groups; d) they always condition the person's behavior either to limit or motivate the performance of action; e) in many cases, they are social constructs, that is, they can be shared by a group of people, which means that they can be transferred from one person to another; f) they can be expressed through the use of verbal or gestural language; g) because they are based on experience, they require the presence of value judgments about the situation that leads to them.

Finally, as already mentioned, attitudes are not born with the person, but, on the contrary, they arise from the so-called cultural learning, which is why they are subject to the conditions of the environment or surroundings in which they are learned, then to understand them, it is necessary to consider the particular way in which the interaction that generated them took place (Gallego, 2000; Barrientos and Arranz, 2019). This same author assures that individuals build certain attitudes towards a specific knowledge "with a view to playing the role that best enables them to live successfully in their community" (p. 24). Therefore, this highlights the importance of the community in which the person interacts and the attitudes that they have built around that knowledge, which, in this case, corresponds to mathematics, its teaching, learning, evaluation, application in daily life and its influence to be professionally successful with social recognition.

2 Methodology

This research process is adjusted to the characteristics of the quantitative approach since it is expected to enunciate the particular characteristics of an academic phenomenon within two different geographical contexts, but with very similar social dynamics. Then this process is not experimental, but at a transversal descriptive level since the data were collected at a specific moment in time corresponding to the second semester of the year 2021, a time when, at a national level, there was an attempt to return to face-to-face activities in many daily activities, but in the educational process, non-face-to-face activities assisted by technological resources continued to predominate.

The field design was followed for data collection since key informants were directly surveyed (Arias, 2012). The population is defined as the totality of students enrolled for the second semester of 2021 in a teacher training program in Mathematics in two higher education institutions of a public nature but located in the capital cities of two border departments of Colombia: one located in the southwest of the country on the border of Colombia and Ecuador, while the other is located in the northeastern border of Colombia with Venezuela.

Hernandez et al. (2018) state that "the sample is a subgroup of the population of interest on which data will be collected" (p. 173), because the sample was selected in a non-probabilistic way through the voluntary sampling technique, it is not possible to make inferences from the results obtained. The sample size was 237 people, 47% of whom reside in the southern border of Colombia, while the remaining 53% reside on the northeastern border of the country.

The survey is used as an instrument for data collection, but given the objective pursued by the research, first, a literature review was conducted on the most commonly used instruments to characterize beliefs, attitudes and emotions as the basic descriptors of the affective domain. The instruments proposed in the works of Caballero et al. (2014), Auzmendi (1992) and Fernández-Cézar et al. (2016) were considered the foundation for the construction of the survey used in this inquiry. Table 2 presents a summary of the composition of the instrument. It should be noted that the statements of the items were written in the affirmative.

Table 2 Composition of the survey used

Aspect to evaluate	N° of items	Scale of measurement
Demographic and academic profile	4	Multiple choice with only one answer consistent with the topic (university, gender, age and semester of study)
Beliefs towards mathematics	36	Likert scale with five levels of

Attitudes towards mathematics	25	acceptance distributed as follows: two levels of disagreement, indifference and two levels of agreement.
Emotions that mathematical study brings about	10	

Once the preliminary version of the survey was available, the peer review process was carried out, which was reviewed and subsequently endorsed by two Spanish teachers with experience in the subject. Subsequently, a Google form was created to administer the survey. Students were contacted through institutional e-mails and a reasonable time of three weeks was allowed for the voluntary completion of the survey.

Once the time window for data collection was completed, the Excel file was downloaded and then exported to SPSS statistical software version 25. Finally, a variety of descriptive analysis processes were carried out, including the reliability analysis of the survey.

3 Results and discussion

Given that it is expected to establish a comparison between the descriptive results obtained in each educational institution, the following considerations are taken into account:

a) The university located on the southwestern border of the country (bordering Ecuador) is identified as IES_1, while the university located on the northeastern border of Colombia (bordering Venezuela) is identified as IES_2.
b) Because the number of participants in each educational institution was different, only percentages are reported for each response option, obtained from the number of students in each educational institution.

The demographic profile of the participants is shown in Table 3, where it is observed that there is a predominance of men regardless of the educational institution, a situation that coincides with what Gonzalez (2003) affirms, citing Sells, who "identified mathematics as the critical filter that conditions many women's accesses to careers related to this subject, and that ... translates into less access to high salaries and prestigious occupations" (p. 130). In the same line of argument, Gil (2003) concludes that gender influences the affections that students exhibit towards the subject. Regarding the semester in which the students are studying, it was observed that students between the seventh and ninth semesters coincide in participation in both institutions; and for age, it is noted that the average age in IES_1 (21.6 years) is slightly higher than that obtained in IES_2 (20.8 years).

Table 3 Demographic and academic profile of the participants by an educational institution

Appearance	Response options	IES_1	IES_2
Genre	Female	46.6%	44.0%
	Male	53.4%	56.0%
	Total	100.0%	100.0%
Academic semester	Semester I to III	18.4%	39.5%
	From IV to VI semester	33.1%	22.1%
	From VII to IX semester	36.0%	36.7%
	In X Semester	12.6%	1.7%
	Total	100.0%	100.0%

Age range	Between 16 and 20 years old	43.7%	46.8%
	Between 21 and 25 years old	40.8%	49.5%
	Between 26 and 30 years old	15.5%	3.7%
	Total	100.0%	100.0%

Quero (2010) emphasizes that reliability and validity are two desirable characteristics in any measuring instrument, where "validity refers to the fact that it measures what it is intended to measure; reliability refers to the accuracy with which a measuring instrument measures what it measures" (p. 249). To measure internal consistency as a measure of reliability, Cronbach's alpha coefficient is used. In this case, a measure is expected to indicate the degree to which the items used in the survey allow to measure the variable "attitude towards mathematics". From the information shown in Table 4 and from the values obtained for Cronbach's alpha coefficient, it can be concluded that the proposed items measure satisfactorily the attitude towards mathematics, regardless of the educational institution in which the informant is studying.

Table 4 Construct validation report "Attitudes towards mathematics".

Source	**Valid cases**	**Cronbach's Alpha Coefficient**
Total students	237	0.865
IES_1 students	112	0.869
IES_2 students	125	0.843

3.1 Characterization of attitudes toward mathematics

As mentioned above, the social context in which the student interacts influences the attitudes that the person has built around mathematics. For this reason, the first approach to this assumption was to determine the mean score of the construct for each of the students surveyed, and from these scores, the box-and-whisker diagram was constructed for each educational institution. The main one is that the overlapping of the two graphs allows concluding that there are no significant differences between the mean scores that the students of both institutions have assigned to the attitudes they experience around mathematics. On the other hand, IES_1 shows a group of students with contradictory positions, given the presence of atypical data above and below the whiskers of the diagram, while IES_2 highlights the presence of a group of students who have manifested attitudes of rejection towards the study of mathematics.

[See Figure 1]

Figure 1: Comparative mean score of the construct "Attitude toward mathematics".

This situation could coincide with what was stated by Roa and Fernández (2020), who in their research highlight that one out of two respondents did not feel motivated in the exercise of the teaching profession, propitiated by various causes within which the working conditions, the low participation of students and especially, apathy towards certain subjects stand out. In this sense, Díaz and Vanegas (2017) point out that "there is a tendency to negative emotions and beliefs that discourage, generating self-conceptions from which, most do not feel they are good students in mathematics or interested in its contents" (p. 8). To this panorama

could be added the situation that many people enter teacher training programs in universities, as the only training option due to their poor results in State tests, so they are people who do not possess the vocation of being teachers. In this sense, Prada et al. (2021) refer to the topic highlighting the influence that the teaching vocation can have on their students, "it is important to analyze the relevance of the teaching vocation, taking into account that teachers are the guides in the learning of students and the love and taste for this profession is the trigger of a good education" (p. 222).

The following is a detailed analysis of each of the attitudes presented to the respondents to obtain their perceptions. To facilitate the interpretation of the results, the authors have decided to report the percentage of acceptance of each of the items reported in both educational institutions. This percentage is obtained by adding the two levels of acceptance referred to in the original measurement scale (Agree and Strongly Agree). From the information displayed in Table 5, it can be commented that:

a) The opinions of at least 80% of the respondents (regardless of the university where they study) coincide in valuing the importance of the subject within the school curriculum and in their future professional performance, recognizing that they should continue preparing themselves to reach a high level of mathematical competencies. The research by Bazán and Aparicio (2006) highlights two important aspects: the importance of mathematical knowledge in the academic training of people entering the educational system, regardless of their level of schooling, in contrast to the high levels of undesirable performance observed in this subject. For his part, Gairín (1990), after exploring the possible relationship between mathematical learning and student attitudes, concludes that such attitudes are conditioned by family, curricular and personal factors. In a complementary way, the research by Prada et al. (2017), Hernández-Suárez et al. (2017), Ramírez et al. (2018) and Manrique et al. (2019) recognizes the contribution that mathematical knowledge and processes offer both for everyday life and in the future professional performance of people based on the development of logical-mathematical thinking.

b) Regarding the satisfaction produced by mathematics itself and the resolution of mathematical problems, it is observed in the students of both universities percentages of favorability range between 75% and 85% of the cases. In Fernández-Cézar et al. (2018), the preponderant role that affects have in the teaching and learning processes are highlighted, which coincides with the results of the research of Agne et al. (1994) who recognize the influence on the academic performance of students, exerted by the attitudes and beliefs of both the teacher and the student. In Bazán and Aparicio (2006), it is stated that "from affectivity, it slowly moved towards rational life" (p. 11), therefore, affectivity cannot be separated from cognition in the formative process.

c) In IES_1 students, percentages that exceed by 15% of the opinion given by IES_2 students are evidenced in two opposite positions: on the one hand, there are those students who claim to enjoy talking about mathematical topics or solving problems in the company of other students, as referred by García (2012) in that "school learning is a constructive social activity that the student performs, particularly together with their peers and the teacher, to achieve knowledge and assimilate an object of knowledge, determined by the school contents" (p. 104). In this sense, Alarcón et al. (2018) recognize essential demands of today's society in terms of teaching and learning processes, the development in people of teamwork and the capacity for personal autonomy; and, on the other hand, those who express not wanting mathematics to be an essential part of their professional future possibly motivated by the uninteresting way in which it has been presented and developed in the teaching process. Regarding this situation, De Guzmán (2007), after a historical review of the way mathematical

knowledge and its teaching have evolved in response to social demands and technological advances, suggests an ideal to channel "the intense efforts to transmit heuristic strategies suitable for problem-solving in general, to stimulate the autonomous resolution of real problems, rather than the mere transmission of appropriate recipes" (p. 27). 27), then it is hoped that mathematical activity in school does not become a reductionist activity of applying solution algorithms that are far removed from mathematical reasoning and true learning.

d) IES_2 students show a very favorable attitude toward complementing their mathematics education through optional courses, given that they feel motivated and confident when solving mathematical problems. In these aspects, 60% of the students of IES_1 express a favorable position, but it is at least 8% lower than that of the students of IES_2. In Fernández-Cézar et al. (2018), it is assumed that "today's society demands people competent in mathematics, as well as willing to adapt and readapt to technological changes; in short, apt for lifelong learning" (p. 330), thus reinforcing the term "being mathematically competent" (Flores and Moreno, 2011, p. 7) coined by the Organization for Economic Cooperation and Development (hereinafter OECD), which implies that the student should not only know mathematical concepts but should possess the ability to apply them in the solution of problems offered to them by society since mathematics has a social and cultural function (Duarte et al., 2018).

Table 5 Percentage of respondents' acceptance of Attitudes towards mathematics.

Referenced items	**IES _1**	**IES_2**
A1. I consider mathematics a very necessary subject in my studies.	84.5%	89.0%
A2. I am not very good at mathematics.	5.8%	2.8%
A3. Studying or working with mathematics does not scare me at all.	68.9%	64.2%
A4. Using mathematics is a fun activity for me.	77.7%	70.6%
A5. Mathematics is too theoretical to be of any use to me.	11.7%	7.3%
A6. I want to gain a deeper understanding of mathematics.	84.5%	89.9%
A7. Mathematics is one of the subjects I am most afraid of.	5.8%	7.3%
A8. I am confident when faced with a math problem.	64.0%	72.4%
A9. I enjoy talking with other people about math topics.	81.5%	66.1%
A10. Mathematics may be useful for someone who decides to study an engineering program, but not for the rest of the students	5.8%	4.6%
A11. Having a good knowledge of mathematics will increase my chances of getting a job.	69.0%	61.5%
A12. When faced with a math problem I feel unable to think clearly.	3.9%	10.1%
A13. I am calm and collected when faced with a math problem.	64.1%	62.4%
A14. I find mathematics enjoyable and stimulating.	84.5%	77.0%
A15. I hope to have little use for mathematics in my professional life.	24.3%	5.6%
A16. I consider that there are other subjects more important than mathematics for my future career.	12.6%	11.9%
A17. Working with math makes me feel nervous.	5.8%	4.6%
A18. I do not get upset when I have to work on math problems.	67.0%	49.5%
A19. I would like to have an occupation in which I had to use mathematics.	84.5%	85.3%
A20. I get great satisfaction from solving math problems.	75.7%	85.3%
A21. For my future professional career, mathematics is a subject	78.6%	64.3%
A22. Math makes me feel uncomfortable and nervous.	2.9%	5.5%

A23. If I set my mind to it, I believe I would become proficient in mathematics.	84.4%	87.1%
A24. If I had the chance, I would enroll in more math courses than are required.	63.1%	74.3%
A25. The content taught in mathematics classes is not very interesting.	17.4%	6.4%

Finally, and based on the motivation of this study, it can be affirmed that the results obtained from these two groups of teachers in training in the area of mathematics corroborate the influence that social and educational contexts have on the educational process, in which all actors (parents, relatives, teachers, and classmates, among many others) contribute to the cultural learning of students and therefore to the attitudes they develop around the study of this essential discipline for the competent performance of people.

4 Conclusions

This research was carried out with teachers in training in mathematics from two different geographical locations, but from the data collected, it was possible to verify that the characteristics of the social context have influenced the construction and appropriation of a series of attitudes towards mathematics, which are similar in both groups of students.

As highlighted in the background review, there is a strong univocal relationship of correspondence between the affective component and the learning process (in the case of students), but these feelings can also be transmitted by teachers to their students in the teaching process given the influence of the educator on his students; therefore, it is reiterated that attitudes are not born with people, but are the result of the experiences lived individually or in groups, which propitiate predispositions to action.

Researchers such as Piaget highlight the strong relationship between the development of feeling and cognitive skills in people since they are inseparable because every exchange with the environment presupposes, at the same time, structuring and valorization.

Because of the above, it can be affirmed that no significant differences were found between the attitudes exhibited by both groups of informants; the importance they show towards study and the acquisition of mathematical competencies is highlighted, since they carry it out in a motivated and enthusiastic way. Further research on the influence of feelings on the processes of teaching and learning mathematics is expected.

5 Conflict of interest

The authors state that the research was conducted without any commercial or financial interest.

6 Authors' contributions

All authors contributed to the direction and objectives of the AAGS. RPN designed the questionnaire and general data collection strategies. CAHS led the creation of figures and with contributions of ongoing comments. AAGS, RPN and CAHS edited the final manuscript.

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Figure 1