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Gender as a Differentiating Factor in Mathematics Anxiety of Pre-Service Teachers

Erika Franco-Buriticá [1], Iris Betzaida Pérez Almeida [2], Carmen León-Mantero [1,*] and José Carlos Casas-Rosal [1]

[1] Department of Mathematics, Faculty of Education and Phycology, Universidad de Córdoba, 14071 Córdoba, Spain; z72frbue@uco.es (E.F.-B.); jcasas@uco.es (J.C.C.-R.)
[2] Center of Studies for Sustainable Development (CEDS), Universidad ECOTEC, Km. 13.5 Samborondón, Samborondón EC092302, Ecuador; iperez@ecotec.edu.ec
* Correspondence: cmleon@uco.es

Abstract: Developing mathematical competencies in future teachers requires particular attention to both cognitive and affective aspects. A positive attitude towards mathematics increases enjoyment, motivation, and confidence when working with the subject. It also reduces the anxiety of facing activities and problems and gives greater value to the academic and professional usefulness of mastering mathematical knowledge. These attitudes will also be reflected in their future teaching practice. For this reason, it is of great interest to study the attitudes of this critical group since, despite the numerous investigations carried out in this field, the influence of variables, such as place of origin or gender, on the attitudes and, in particular, on the attitudinal factor that best explains them, anxiety towards mathematics, has not yet been clarified. This work has analyzed the attitude and anxiety of 235 future teachers who study in rural and urban environments. The results show that gender is a differentiating factor in anxiety, with similar results in the schools of the two environments. However, the differences between men and women are more pronounced in the rural environment.

Keywords: attitudes; mathematics; anxiety; gender; urban; rural

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1. Introduction

Mathematics education provides citizens with competencies that enable them to deal with problems that arise in everyday life at personal, academic, and professional levels. In this sense, achieving appropriate mathematical competencies can prepare individuals to analyze, reason critically, solve problems, communicate results effectively, and draw conclusions [1].

In particular, the mathematical skills developed by future teachers and professors are of crucial importance in the teaching–learning–assessment process of their future students. Therefore, their initial training should focus on acquiring a solid knowledge of school subjects and projecting positive attitudes towards the contents with which they will be dealing with their students [2–4].

The research focused on the affective domain in mathematics education has received recent interest from researchers in the field because it influences the appropriate development of mathematical competencies. The elements that make up the affective domain arise when a person deals with situations involving mathematical knowledge, processes, and procedures in practice [5–9].

It is, therefore, of great importance to investigate the cognitive and affective aspects of one of the most influential groups in society, trainee teachers. In the first levels of education, their tasks include teaching mathematics, so their attitudes towards mathematics must be favorable, as they will be projected in all aspects of their teaching work. On the other hand, they will have the responsibility to help their students to construct their mathematical thinking and cultivate their own beliefs, emotions, feelings, and attitudes [10].

In this sense, research that examines the attitudes towards the mathematics of future teachers shows that, although they positively value the usefulness of mathematics and enjoy situations that require the application of mathematical concepts and results, facing them causes them anxiety [11–13]. Consequently, we will focus our attention on the study of the construct of attitude towards mathematics in pre-service teachers through the different factors that explain it, focusing on the one that influences it most, anxiety towards mathematics [3,14–16].

Although the concept of attitude has been widely studied in the fields of psychology and education, there is no homogeneity regarding its definition. Callahan [17] consider attitude a mental state that can be modified over time, therefore predisposing the individual to particular situations that influence his/her behavior. Allport [18] adds that attitudes are mental states acquired through lived experiences and modify behavior. Aiken [19] takes up the previous definitions and adds that attitude is a positive or negative response of the subject and does not depend on the field of study that the subject has followed during his or her academic training.

Subsequently, Gómez-Chacón [5] approach the definition of attitude as an evaluative predisposition, positive or negative, which influences the subject's intentions and, therefore, the way he or she behaves towards the object that provokes the attitude. Thus, the literature review carried out by Pedrosa-Jesús, León-Mantero, and Cuida [20] summarizes that attitudes are considered predispositions that are acquired through experiences or psychological developments; that influence or generate an impact on behavior; that can be positive-favorable or negative-favorable; and that appear around objects, people, situations, concepts, or subjects.

Attitudes toward mathematics are characterized by appearing at any age in a subject. However, some studies show that they are optimistic at an early age, change, and become more hostile as the students advance in their studies [21]. They can also be positive towards one part of the subject and negative towards another. They are reflected in students' behavior through feelings toward the teacher or towards a particular type of task within the subject [22].

Several authors consider that attitudes are composed of three components: the cognitive component, or that which is manifested in the beliefs and conceptions that underlie such an attitude; the affective component, which is expressed in the feelings of approval or rejection that it generates in people; and the intentional component, which refers to the behavioral part of the individual in the face of the stimulus that has generated such an attitude [10,18,22].

Likewise, since attitudes cannot be measured directly, in this study, we have considered the dimensional factors proposed by Auzmendi Escribano [22]. These are as follows: anxiety, which refers to the fear that the student feels towards the subject; usefulness, which relates to the value that the student brings to mathematics in his or her academic or professional future; pleasure, which refers to the enjoyment experienced during the study or use of mathematics; motivation, which relates to the degree of enthusiasm with which the student initiates and sustains a task; and confidence, which refers to the feeling of security before one's ability in the use of mathematics.

A review of the literature on attitudes toward mathematics allows us to observe the different approaches from which they have been observed, analyzed, and compared. On the one hand, some studies compare attitudes in relation to sociocultural variables, in which significant differences are found between participants according to gender, place of residence, race, or ethnicity.

Thus, Awofala and Ojaleye [23] conducted a study with 480 Nigerian pre-service mathematics teachers in which they found subtle differences in attitudes towards mathematics according to the gender of the respondents. They also found that 73.7% of the variation in attitudes towards mathematics was explained by eight variables: gender, practical or utilitarian value, disciplinary value, cultural value, social value, moral value, aesthetic value, and recreational value.

Similarly, Flores López and Auzmendi Escribano [24] analyzed the attitudes toward mathematics among university students, finding differences in attitudinal factors between participants belonging to different ethnical groups. Similarly, Iben [25] found significant gender and racial differences in mathematics confidence in Australian, Japanese, and American students.

Positive correlations have also been found between attitudes toward mathematics and academic achievement. Indeed, in work by Bakar et al. [26] on university students, significant positive relationships were found between their attitudes, achievement motivation, and academic performance. Similarly, Subia, Salangsang, and Medrano [27] found a significant positive relationship between attitudes and performance in mathematics for a sample of 105 pre-service primary school teachers.

On the other hand, there is evidence of the positive impact of the acquisition of mathematics training and its didactics on attitudes towards the subject. An example of this is the research conducted by Hill and Bilgin [28] among 278 future teachers, whose results show that previous mathematics studies significantly influenced their attitudes toward the subject. Similarly, León-Mantero, Maz-Machado, and Jiménez-Fanjul [29] compared attitudinal factors in pre-service teachers in the first and third years of the primary education course and found greater motivation and appreciation of the usefulness of the subject among third-year students.

However, the studies undertaken by the participants are a factor that causes great differences in their attitudes. In this respect, engineering students generally show positive attitudes and say they value the subject positively from an academic and professional point of view [30,31].

The work carried out by Alisinanoğlu, Güven, and Kesicioğlu [32] is noteworthy concerning teachers or trainee teachers. In this research, it was observed that the attitudes of future preschool teachers toward mathematics education do not change according to the branch of secondary school knowledge in which they have graduated. However, they differ significantly according to the school year in which they are studying at the time.

In the study by Nortes Martinez-Artero and Nortes Checa [33], conducted with a sample of 1150 future teachers, it was found that, in general, one-third of the students had a negative attitude (considered as such if it was lower than 3), but that the final year students had a higher attitude. The highest-rated item was the trust factor, and the lowest was the liking factor.

Moreover, although trainee teachers generally value the usefulness of mathematics in everyday life, academic training, and future professional performance, they report feeling anxious when faced with tasks that require mathematics and problem-solving [11,15]. In this sense, results show that anxiety is the factor of attitude toward mathematics that most significantly and negatively influences one's attitude and enjoyment of mathematics classes [3]. It also affects the learning of the subject and increases the perception of its difficulty [34].

However, this dimension of attitude shows the most remarkable differences when compared with variables, such as gender or the academic year in which the future teachers are enrolled. Indeed, Sánchez Mendías, Segovia Alex, and Minán Espigares [15] analyzed anxiety and confidence in a sample of 488 trainee primary school teachers. The results showed lower anxiety and confidence levels than would be expected of a future teacher.

On the other hand, for some time, researchers have been interested in comparing the achievement of students in rural and urban areas due to the significant differences that may occur in their respective social and organizational environments [35].

Studies investigating the influence of the type of environment (rural or urban) on attitude and anxiety toward mathematics are very scarce. For example, Franco-Buriticá et al. [36] showed greater anxiety toward mathematics and lower confidence and liking for mathematics in rural environments. However, higher levels of motivation and perceived usefulness were also found.

Another example is the study by Fernández-Cézar et al. [37], which investigated the effect that the environment could have on the attitudes toward mathematics among students in a Science, Technology, Engineering, and Mathematics (STEM) extension program. In this case, the results showed no significant differences between rural and urban areas.

Similarly, another study analyzing the results of the PISA report shows that students from urban environments have more positive attitudes and a favorable impact on achievement [38].

The large variability in the results obtained on attitudes towards mathematics, particularly on the dimension of anxiety, and concerning the variables of students' gender and type of environment calls for further research in this area. This idea is also supported by Hanula et al. [6], who agree that pre-service teachers' attitudes toward mathematics considerably impact teaching and learning mathematics. For this reason, they consider it vital to continue analyzing the attitudes toward mathematics in this group. It will also make it possible to describe and understand their assessments and thus make proposals to try to solve this problem. However, they also admit that, although it is necessary to tackle it, it is an important challenge.

Therefore, this paper aims to analyze the attitude towards mathematics through its components and, in particular, the anxiety expressed by secondary school students belonging to Higher Teacher Training Institutions (where teacher training takes place) located in rural and urban environments of the Tolima region of Colombia, studying the differences that exist between men and women. The aim was to analyze whether the type of environment moderates these differences in any way.

2. Materials and Methods

This study is a descriptive and exploratory investigation carried out with two groups of students belonging to the Superior Normal School of Tolima in rural and urban areas.

2.1. Population and Sample

The study's target population was the students of the Higher Teacher Training Colleges of the Tolima region. These are future teachers who are trained in this region. A sample of 235 students was taken from Tolima, Colombia's only four teacher training institutions. These institutions and the sample collected in each of them were ENS Ibagué (96), ENS Icononzo (56), ENS Villahermosa (35), and ENS Fabio Lozano Torrijos (48). The first is located in an urban environment, in Ibagué, the region's capital, with more than 500,000 inhabitants. It should be noted that it is the only Normal School in Tolima located in an urban environment. The others are located in rural areas. These three municipalities have a population of about 10,000 inhabitants, with limited resources and an economy based on agriculture that develops in small farms. Therefore, 59.1% of the selected pre-service teachers are trained in rural environments. This sample distribution by schools and rural/urban environments was designed following stratified sampling according to these two criteria.

The objective sample size was established at 250 since it had a maximum error of 6% and a confidence level of 95%. From this, a sample of students was selected from each of the four Normal Schools in the Tolima region. The sample size in each institution was approximately proportional to the number of students in the school. Permission was requested from the Directorate of the Centers, which allowed a random selection of a group from the institute so that the students were asked to respond voluntarily and anonymously to the questionnaire during class on one of the first days of the school year. Finally, the sample collected was 235, and the sampling error was 6.2%.

The sample consisted of 51.9% of female students aged between 15 and 21 years, with a mean age of 16.67 (SD = 1.348). The questionnaires were filled in face-to-face, anonymously, and voluntarily on the day that classes started. It was performed in those groups where one of the contributors to this study was going to teach. Therefore, the sample was purposive and convenient. Respondents were informed that their answers to the questionnaire would

not affect their marks in the subjects in which they were asked to complete the forms. The response rate was over 90% of those asked to complete the questionnaire.

2.2. Information Collection Instrument

The Likert-type scale was used to measure attitudes toward mathematics, designed and validated by Auzmendi [19] with students in Spain. This scale has been one of the most widely used and recommended in the Ibero-American environment by different members of the educational community [39–42].

This Likert scale has a total of 25 items that the student must evaluate according to their degree of proximity or distance to the statements made in each one. The student must choose only one answer from the following, according to their opinion: strongly disagree = 1, disagree = 2, neutral = 3, agree = 4, and strongly agree = 5. It should be clarified that some statements were inverted when the data were entered into SPSS for analysis, as they were initially stated with a negative attitude toward mathematics. That is, high values for these items indicated a negative attitude toward mathematics. Thus, after the change, all responses showed a positive attitude towards mathematics. Attitude can be estimated by adding or averaging the responses to all 25 items, as is typical for instruments with Likert-type items. In this case, the responses were averaged. The items that were reverse-coded are labeled with the letter i in Table 1.

Table 1. Factor distribution of 25 items of the Auzmendi attitude scale (1992).

Factors	Cronbach's Alpha	Items
Anxiety	0.795	2i, 3, 7i, 8, 12i, 13, 17i, 18, 22i
Linking	0.730	4, 9, 14, 24
Utility	0.707	1, 6, 15i, 16i, 19, 21
Motivation	0.658	5i, 10i, 25i
Confidence	0.623	11, 20, 23

Since the anxiety factor is a conceptually negative factor concerning attitude, and because of this coding, which proposes to score responses positively regarding attitude towards mathematics, it is essential to note that high values in the anxiety factor score indicate a low degree of anxiety towards mathematics.

Table 1 shows the five-dimensional factors proposed and analyzed in Auzmendi Escribano's instrument [22] and the Likert scale items belonging to each factor. This same distribution of items was used in the present study. The analysis of results shown in the following section is focused on the anxiety factor. Coefficients alpha for the scales used in the analyses are reported in Table 1.

2.3. Data Analysis

Initially, the data were collected, tabulated, and subsequently transferred to the SPSS software database in its version 24, and using this, some procedures were applied, such as the generation of tables and comparative graphs on each of the factors that, according to Auzmendi Escribano [22], constitute the attitude towards mathematics. Specifically, a descriptive and inferential statistical analysis was carried out in which anxiety was taken as the central variable, and the explanatory variable was the gender of the participants. Firstly, a descriptive comparative study was carried out to compare the mean values of each scale factor between men and women, estimated by adding the responses of each item. It was carried out mainly through bar charts of means with 95% confidence intervals for rural and urban environments. The comparison of anxiety between men and women in the two areas was then carried out using the non-parametric Mann–Whitney test to compare means once the normality of the variables involved had been rejected by using the Kolmogorov–Smirnov test. Effect sizes were also calculated for the differences found.

3. Results

The analysis of the information using the Auzmendi scale yielded the results shown below, focusing on those directly related to the proposed objectives. It should be remembered that high values of the anxiety variable indicate a lower degree of anxiety.

Evidence was found that among students from urban regions, males present less anxiety towards mathematics than women. According to the results, women are afraid of mathematics and affirm that they do not think well when approaching a problem associated with this subject. It makes them nervous, uncomfortable, and upset (Figure 1). This fact has been a trend in various studies related to the mathematics [6,8].

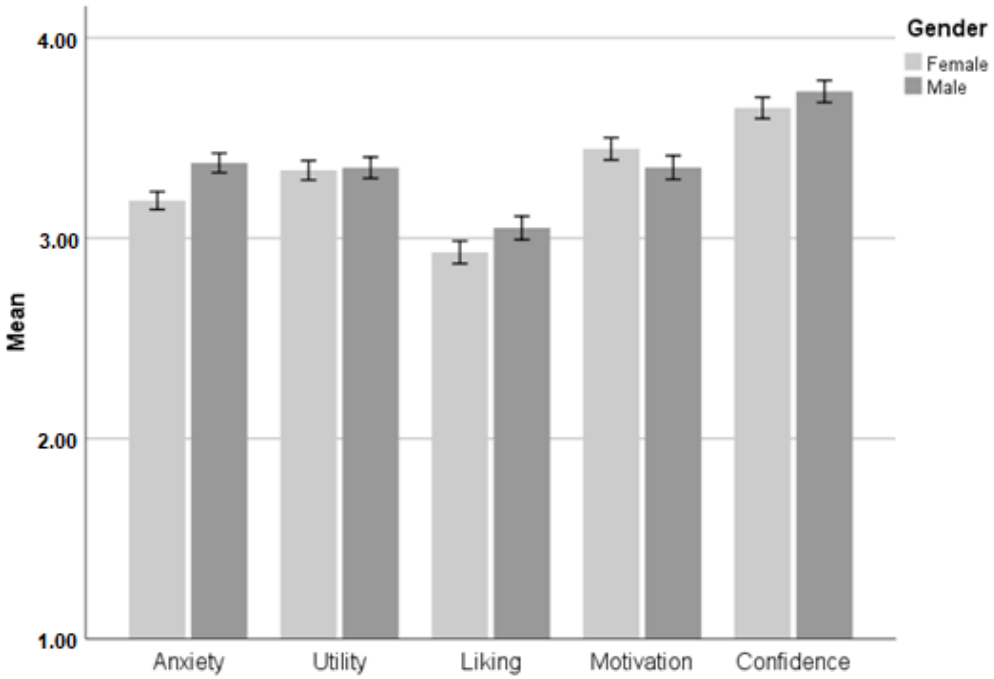

Figure 1. Comparison by gender of the attitude towards mathematics in urban environments with error bars representing the 95% CI.

Regarding the additional factors, the confidence and utility of men and females in urban areas were similar. However, more positive values were observed in liking mathematics for males, although with lower motivation. Examining the responses to the 25 items in more detail and comparing the mean values of men and women in each, at a descriptive analysis level, it seems that males are more inclined to believe that mathematics increase their job opportunities, they feel satisfaction when solving problems, they have fun using mathematics and talking about it, and they consider it pleasurable. Given the opportunity, they would enroll in additional math courses. Therefore, they believe that if they put their minds to it, they will master it well. On the other hand, females have a better attitude towards mathematics than males only in the motivation factor and similar in utility, which means that they consider mathematics necessary and would like to have a more profound knowledge in the area that motivates them to face matter. However, these aspects need to be further investigated.

Regarding the institutions in rural areas, it can be observed that women have higher motivation levels toward the subject than men and a similar degree of utility (Figure 2).

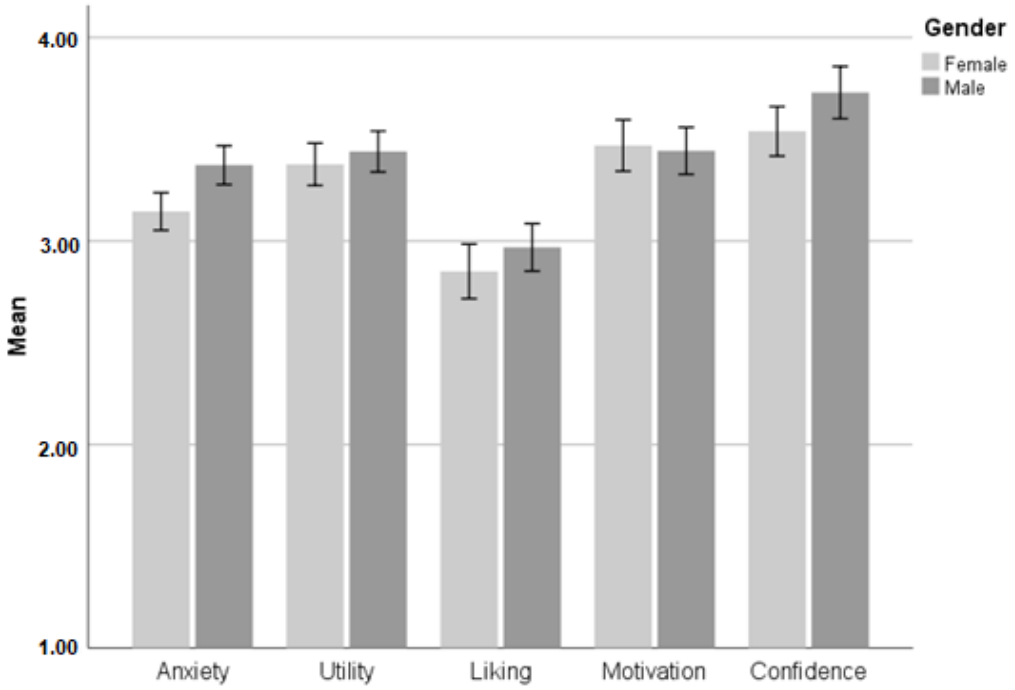

Figure 2. Comparison by gender of the attitude towards mathematics in rural environments with error bars representing the 95% CI.

The anxiety factor is striking because, although with behavior similar to that found in urban areas, the difference between men and women seems to be amplified. This gender behavior has been a trend in the scientific literature (more significant anxiety towards mathematics in women than in men). From all these results at the descriptive level, it seems to be deduced that females from institutions in rural areas might have a worse attitude towards mathematics than males.

This larger difference in anxiety levels between men and women in rural settings that seems to be observed visually is of particular interest since, if confirmed, it would show that the type of environment in which teaching takes place influences the anxiety gap between men and women. For this reason, the mean values are verified below as indicators of this attitudinal factor about gender in the two environments.

Table 2 shows that the average value corresponding to the anxiety dimension in women is lower than that of men, both in rural and urban settings. These results are in line with what has been found in previous studies [14,15,29,42]. Therefore, in both environments, the most common theoretical approaches in the scientific literature are met, with a greater tendency for the female gender to be more anxious.

Table 2. A descriptive comparison of the anxiety of men and women in the two environments was analyzed.

Environment	Gender	n	Mean	Std. Deviation
Rural	Male	67	3.365	0.586
	Female	72	3.134	0.563
Urban	Male	46	3.369	0.654
	Female	50	3.181	0.661

However, as previously observed, the gender gap in mean anxiety scores appears greater in rural than urban environments. This may be due to the difference in context and work activities in each of the municipalities.

Next, we carried out this analysis inferentially. First, we checked if the variable has a normal distribution. As can be seen in Table 3, when performing the normality test for

data from rural settings, the limit probabilities obtained (0.015 and 0.001, respectively) show that the anxiety of men and women does not have a Gaussian bell shape; therefore, when comparing the anxiety of men and women, the non-parametric Mann–Whitney test was applied.

Table 3. An inferential comparison of the anxiety of men and women in the two environments was analyzed.

Environment	Gender	Normality Test		Comparison Test	
		Statistic	*p*-Value	*p* Value	Effect Size
Rural	Male	0.978	0.015	0.001	0.401
	Female	0.969	0.001		
Urban	Male	0.984	<0.001	<0.001	0.298
	Female	0.982	<0.001		

Once carried out, the value of the limit probability corresponded to 0.001, which means that the differences are significant between men and women in their level of anxiety towards mathematics. This behavior is in line with several previous studies with students in which females were found to be more anxious about math than males. The effect size calculation informs us that the importance of gender on anxiety is medium (between 0.3 and 0.5).

The mean values of the Anxiety dimensional factor is also worth analyzing in urban environments to verify that what was observed descriptively is maintained, where it was appreciated that this influence is less.

When performing the normality test in urban environments, even though the sample size is much larger, it cannot be stated that anxiety has a Gaussian bell shape in men and women, with *p*-values less than 0.001. For this reason, as in the previous case, the non-parametric Mann–Whitney test was applied, resulting in the differences between men and women in terms of the anxiety variable being also significant in urban environments. However, the effect size is significantly smaller than that in the previous case and can be considered low (less than 0.3). It can be seen by comparing both values that in the rural environment, the effect size is 35% higher than that found in the urban environment ($0.401/0.298 \times 100\% = 134.56\%$).

Therefore, it can be affirmed that the environment in which pre-service teachers develop their learning can moderate the difference in the degree of anxiety between men and women so that in rural environments, the gap widens. Women from rural environments seem to show higher levels of anxiety.

4. Discussion and Conclusions

In general, it is observed that the attitude towards mathematics is more favorable in male students, both in rural and urban environments. In the former, it is also observed that only in motivation do women present higher values. In urban environments, women also have a greater liking for mathematics than in rural environments.

Although the behavior found in women's anxiety is in line with the most frequent result in the literature, in which women present higher levels of anxiety than men [9,15,16,29,42], it has been observed that this gap is even more remarkable when they develop their studies as future teachers in institutions located in rural environments.

Among other factors, the differences in the anxiety gap towards mathematics among students from rural and urban areas could be explained because in rural environments women are frequently entrusted by their closest relatives to carry out domestic tasks. These consist, on many occasions, of arduous working hours that prevent their constant attendance at class and participation in educational practices in mathematics, among others. Another reason could be the lower use of active teaching–learning methodologies, which

could negatively affect females, i.e., using methods that require students to engage in their learning by thinking, discussing, investigating, and creating [42].

This information can be a starting point for taking measures in institutions in both settings, especially in rural settings, so this gender gap in anxiety towards mathematics is reduced or at least not increased concerning the institutions located in urban environments.

Finally, it can be said that, although there are points of comparison between the attitudes towards mathematics among the students of teacher training institutions, the average grades or overall average scores of most of the dimensional factors of the attitude towards mathematics (Anxiety, Confidence, Utility, and Motivation) are in the best of cases between values 3 and 4, that is, just above the neutral value 3.

These results indicate that the pre-service teachers participating in this study have a slightly positive attitude towards mathematics in the factors mentioned, i.e., the average values obtained are at the neutral value of three or, in many of them, below that value. From this, we can deduce the need for teacher educators to develop interventions to modify the attitudes towards mathematics for future teachers, taking into account how these influence their academic performance [26,27] and that the anxiety or confidence they feel when working with mathematics influences the development of their future teaching work [10].

In light of the results, it is essential to carry out comparative studies with students from other teacher training schools to determine if the results are similar or if the geographic environment variable would imply a difference that can be generalized to other territories.

Given that the geographical delimitation of the study is the Tolima region of Colombia, where there is only one Normal School in an urban environment, the main limitation is that the differences found could also be due to the school effect. The strict normative regulation to which Normal Schools in Colombia are subjected and the great differences in socio-economic contexts suggest that the environment is the main effect. However, future studies must expand the population to other regions so that more normal schools in both environments can be included.

Other of the study's limitations was that all the participants did so voluntarily, which means that the subjects may already have positive attitudes toward mathematics and may represent only a part of the population.

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Institutional Review Board Statement: The participants in this study were all legal age at the time of completing the questionnaire. The surveys were conducted in the facilities where they usually receive teaching, randomly, anonymously, and voluntarily since they did not request personal data of the participant. Each answer is coded with an alphanumeric code that identifies the degree and number of the questionnaire.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

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