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Anxiety towards Mathematics in Middle School Students in Tuxtepec, Oaxaca

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Abstract

Anxiety towards mathematics has been a phenomenon that is frequently present in students. In the Mexican context, it has been a severe problem observed since secondary education. According to the results of the Program for International Student Assessment of the Organization for Economic Cooperation and Development (OECD), 56 % of young people who graduate from middle school in Mexico have a low level of proficiency in mathematics. The present study focuses on determining the dimension that best explains anxiety towards mathematics in middle school students, as well as identifying if there is a difference by gender, age and school grade. For this purpose, the scale designed by Muñoz and Mato (2007) was used, which consists of 24 items that are integrated into five dimensions. The participants were 200 students enrolled in grades 2nd and 3rd of a middle school in the city of Tuxtepec, Oaxaca. For data analysis, reliability, internal consistency and normality were verified, which is acceptable (α: > 0.08). For the hypothesis test, in order to determine if there is a difference by gender, age, and school grade in the five dimensions of the scale used, the ANOVA test is utilized. The findings showed that there is no difference in relation to gender, age and school grade, and that the dimension that best explains anxiety towards mathematics is anxiety before real-life mathematical situations (ATRLMS) followed by anxiety before mathematics evaluation (ATE).

Keywords: Anxiety, mathematics, middle school students.

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1. Introduction

According to the 2018 Program for International Student Assessment (PISA), 56 % of Mexican students obtained a low score in mathematics and only 1 % obtained a performance at the highest levels of proficiency in at least one area (reading, mathematics and science) that this test evaluates, in contrast to the 16 % obtained on average by the other OECD countries. Regarding gender, the results show that male students outperformed women in mathematics by 12 points, when in the rest of the countries this difference was on average 5 % (OECD, 2019).

The PLANEA test is carried out in Mexico by the Ministry of Public Education (SEP) in order to know to what extent students are able to master a set of essential knowledge at the end of secondary education in the fields of language and communication and mathematics (SEP, 2019). According to the results on its last application in 2019, 55 % of third year middle school students had a poor school performance in mathematics and only 9 % reached an outstanding level (Cervantes, 2019).

For some, poor math test scores are the result of anxiety, distress, restlessness, or worry feelings they experience when solving math problems. Over the years, a large body of studies has indicated that many people have extremely negative attitudes towards mathematics, which sometimes amounts to severe anxiety (Hembree, 1990; Ashcraft, 2002; Maloney, Beilock, 2012).

This phenomenon was first reported by Tobias (1978) and since then it has been the main subject of numerous publications (Beilock et al., 2010; Punaro, Reeve, 2012; Hill et al., 2016; among others), showing that it can be considered a serious problem that affects many students around the world.

Conceptually, mathematical anxiety has been defined in the following terms "a general fear or tension associated with situations that involve interaction with mathematics" (Legg, Locker, 2009: 471). Researchers also argue that math anxiety can lead to negative situations such as avoiding math courses and avoiding careers that involve frequent use of math.

On the other hand, Leppävirta (2011: 425) defines mathematical anxiety as "a feeling of tension and anxiety that interferes with the manipulation of numbers and with the solution of mathematical problems". According to Eccius-Wellmann and Lara-Barragan (2016), the causes for anxiety towards mathematics can be classified into three categories: disposition, situation and environment. The first refers to psychological and emotional factors such as attitudes towards mathematics, self-concept and learning styles. The factors that refer to situation are a direct result of mathematics courses, such as the nature of the course and its design, the way it is taught, and so on. The factors that have to do with the environment are those prior to the mathematics courses at school, such as age, gender, undergraduate degree they choose and previous experiences.

Hence the question: What is the dimension that explains anxiety towards mathematics the most in middle school students? And, is there a difference according to gender, age and school grade in relation to anxiety towards mathematics? In order to answer these questions, a research at the Federal Middle School José Vasconcelos, in the city of San Juan Bautista Tuxtepec, Oaxaca in Mexico was carried out. The objective of the research is to determine the dimension that best explains anxiety towards mathematics in middle school students, as well as to determine if there is a difference based on gender, age and school grade.

2. Literature review

Anxiety towards mathematics has been considered one of the greatest problems around the world. It is not a recent problem. Half a century ago, Richardson and Suinn (1972) described math anxiety as feelings of apprehension, tension, or discomfort experienced by large numbers of individuals when performing mathematical tasks or in a mathematical context. In general, higher levels of math anxiety are associated with lower math performance. Although math anxiety may not be the only variable related to math performance, it is a strong predictor. In OECD countries, 14 % of the variation in mathematical performance is explained by levels of mathematical anxiety, and among the highest performing students this relationship remains strong regardless of gender and socioeconomic status (Chang, Beilock, 2016).

Ashcraft (2002) explained that, compared to people who do not have math anxiety, the highly math-anxious individual undergoes lower math achievement and competence. The great interest in the subject of anxiety towards mathematics may arise from the attempt to find solutions to this serious problem. Recent studies by Ersozlu and Karakus (2019) show the trend of scientific studies

in this area. Currently, there is a global push to carry out scientific studies in this field of research in response to the growing problems of modern society in the teaching of mathematics.

Numerous studies over the years have indicated that quite a few people have extremely negative attitudes towards mathematics, sometimes amounting to severe anxiety (Hembree, 1990; Ashcraft, 2002; Maloney, Beilock, 2012). The concept of mathematical anxiety has been associated with cognitive difficulties in performing mathematical tasks, potentially because anxiety interferes with the ability to hold and manipulate information in the mind (working memory), but it is predominantly an emotional problem (Ashcraft, Krause, 2007).

Although many studies treat math anxiety as a single entity, it appears that it may consist of more than one component. Wigfield and Meece (1988) found two different dimensions in the anxiety that four sixth-grade primary and secondary school students experienced towards mathematics: the cognitive and affective dimensions. Dimensions similar to those previously identified by Liebert and Morris (1967) in the area of anxiety towards tests.

The cognitive dimension, called "worry" refers to concern about performance and the consequences of failure, and the affective dimension, called "emotion", refers to nervousness and tension in test situations and the respective autonomous reactions (Liebert, Morris, 1967).

Anxiety interferes with performance, and poor performance increases anxiety, acting as a vicious cycle (Carey et al., 2016). Therefore, it is not a minor disorder since those who are affected avoid mathematics, which affects their academic performance and may condition their future, since they tend to choose activities or university degrees that do not require this subject (Ashcraft, Krause, 2007).

Peper, Harvey, Mason and Lin (2018) explain that many students have problems performing cognitive tasks such as mental arithmetic when they are or feel they are in threatening situations and there are several studies that corroborate these statements (Moore et al., 2012; Schmader et al., 2015). Therefore, to promote students' academic performance, not only should study programs and their teaching be taken into account, but also psychological and emotional aspects that can facilitate their school and professional development (García-Santillán et al., 2017)

2.1. Mathematical anxiety and academic performance and its relationship with gender, age and school grade.

Anxiety towards mathematics seems to worsen as the student gets older. Studies suggest that attitudes towards mathematics tend to deteriorate with age from childhood and adolescence (Wigfield, Meece, 1988; Ma, Kishor, 1997). Anxiety towards mathematics has been observed in children around 6 years of age (Beilock et al., 2010; Krinzinger et al., 2009; Thomas, Dowker, 2000; Vukovic Kieffer et al., 2013) and it increases as children reach secondary education, persisting and worsening during later education and as the student gets older (Wigfield, Meece, 1988; Ma, Kishor, 1997).

The study by Devine, Fawcett, Szűcs et al. (2012) focused on measuring performance in mathematics and levels of anxiety towards mathematics among girls and boys at middle school level. To do this, they applied mental math tests and anxiety tests to 433 middle school students in the United Kingdom. The results showed that there is no gender difference in math performance, but levels of math anxiety and tests anxiety were higher for girls than for boys. Girls and boys showed a positive correlation between math anxiety and tests anxiety and a negative correlation between math anxiety and math performance, but this relationship was stronger for girls than for boys. Regression analyses revealed that math anxiety was a significant predictor of achievement for girls but not for boys.

Reali, Jiménez-Leal, Maldonado-Carreño, Devine and Szücs (2016) carried out a study on the relationship between math anxiety and math performance in which 296 Colombian students participated in an age range of 8 to 16 years old. In this study, they carried out the analysis based on gender and school grade and found that there is no difference in levels of anxiety towards mathematics based on gender. They also identified that there is great variability between grades regarding the strength of association between math anxiety and performance based on gender.

Villamizar, Araujo and Trujillo (2020) have a similar study who analyzed the relationship between mathematical anxiety and academic performance in mathematics of 127 middle school students from Colombia (68 girls and 59 boys) whose average age was 14.34 years old. The results showed that the academic average is high according to the criteria of the Ministry of National

Education of Colombia. In addition, the young girls presented a higher average and a higher level of anxiety than that of the boys. They identified an inverse relationship between mathematical anxiety and academic performance in mathematics, the higher the anxiety, the lower the academic performance.

Stanley, Nyarko, and Frimpong (2021) explore the impact of math anxiety on academic performance in secondary school students in the Bogo district of Ghana. 492 students participated in their study. The findings identified that math anxiety affects students' math performance, and also revealed that gender plays a very important role, with female students experiencing higher levels of math anxiety.

Van Mier, Schleepen and Van der Berg (2019) carried out a study among 124 children in second and fourth grade, identifying that both their level of anxiety and their performance in mathematics were similar between girls and boys, but only among girls, was there a correlation between math anxiety and performance.

Based on the above, the following hypotheses are established to be tested:

H1: There is a dimension that better explains anxiety towards mathematics in middle school students. H2: There is a difference in the dimensions that explain anxiety towards mathematics based on gender. H3: There is a difference in the dimensions that explain anxiety towards mathematics based on age. H4: There is a difference in the dimensions that explain anxiety towards mathematics based on the school grade.

3. Methodology

Our research is approached from the positivist paradigm and the analysis is a descriptive exploratory one. We applied a survey with the anxiety test towards mathematics by Muñoz and Mato (2007). The test is made up of 24 items with response options on a five-point Likert scale, where Totally disagree is 1 and Totally agree 5. The 24 items are integrated into five dimensions whose structure is described in Table 1.

Table 1. Dimensions of the Anxiety towards mathematics scale

Dimension	Ítems
Anxiety towards evaluation (ATE)	1, 2, 8, 10, 11, 14, 15, 18, 20, 22 y 23
Anxiety towards temporality (ATT)	4, 6, 7, y 12
Anxiety towards math problems understanding (ATMPU)	5, 17 y 19
Anxiety towards numbers and math tasks (ATNMT)	3, 13, 16
Anxiety towards real-life math situations (ATRLMS)	9, 21 y 24

Source: designed based on Muñoz and Mato (2007).

The test was applied face to face to 200, second and third year students from General José Vasconcelos Middle School in Tuxtepec, Oaxaca on March 10, 2020. The sample was made up of 50.5 % boys and 49.5 % girls. The average age is 14 years. 69 % of the students were in their second year of middle school and 31 % were in their third (Table 2).

Table 2. Descriptive profiles of the participants

Gender		Frequency	%	∑&
Valids	Male	101	50.5	50.5
	Female	99	49.5	100.0
	Total	200	100.0	
Grade		Frequency	%	∑&
Valids	2º year	138	69.0	69.0
	3er year	62	31.0	100.0
	Total	200	100.0	
Age		Frequency	%	∑&
Valids	13 years old	81	40.5	40.5

14 years old	86	43.0	83.5
15 years old	26	13.0	96.5
16 years old	7	3.5	100.0
Total	200	100.0	

Statistical procedure. First, the reliability and normality tests are carried out: to measure the internal consistency of the items, the Cronbach's alpha and the normality of the data are calculated using the 1-sample KS test. Subsequently, to test the hypotheses that indicate the possible existence of difference in relation to gender, school grade and age, the ANOVA is carried out to determine if there is a difference in means in each of the dimensions indicated in Table 1.

4. Results

The result obtained from the 27 items of the test including age, school grade and gender was 0.897 and the 24 items of the scale give us 0.903 for which both are acceptable and with good internal consistency, so it is considered acceptable according to the criterion suggested by Hair et al (1999) and the validity of the questionnaire was confirmed (Table 3).

Table 3. Test reliability and internal consistency

Cases	N	%	Cronbach`s Alpha	Number of elements
Valids	200	100	0.8976	27
Excludes (a)	0	0		
Total	200	100	0.9036	24

The Kolmogorov-Smirnov test is used to contrast the hypothesis of normality of the population, hence the test statistic is the maximum difference:

$$D = máx\left|F_n(x) - Fo(x)\right|$$

Where: Fn (x) the sample distribution function and Fo (x) the theoretical function or corresponding to the normal population specified in the null hypothesis.

Table 4 shows the values of the KS statistic with *df* and asymptotic significance for each of the dimensions of the test described in Table 1. The values of asymptotic significance (bilateral) provide evidence of the level of normality of the data: in this case the five dimensions have a normal distribution.

Table 4. KS-1 Normality Test

Anxiety dimensions	Grade	Gender	Age
Temporality (ATT)	0.028	0.033	0.156
Evaluation (ATE)	0.037	0.219	0.200
Numbers (ATNMT)	0.023	0.034	0.049
Real-life (ATRLMS)	0.200	0.013	0.196
Comprenhension (ATMPU)	0.310	0.026	0.200

As can be seen in Table 4, the values of the normality test for the three variables: academic grade, gender and age, for the five dimensions of the scale, present normality, so it is feasible to develop the exploratory factor analysis for determine if the matrix is an identity matrix. In addition, the dimension that weighs the most and best explains anxiety towards mathematics in middle school students is identified, as well as the ANOVA to contrast the hypotheses of difference of means in relation to academic grade, gender and age.

With the exploratory factor analysis, the Barttlet test of Sphericity and the KMO sample adequacy measure with Kaiser, the Chi² goodness of fit with n *df* and statistical significance (α), the correlation matrix and the anti-image matrix were developed. The correlation matrix between

the scale dimensions is shown below to see if they present significant correlations, as well as the Barttlet test of Sphericity (Table 5).

Table 5. Correlation matrix and anti-image

Correlation	ATE	ATT	ATMPU	ATNMT	ATRLMS	MSA*
ATE	1.000					.821(a)
ATT	.687	1.000				.836(a)
ATMPU	.623	.681	1.000			.820(a)
ATNMT	.644	.652	.601	1.000		.869(a)
ATRLMS	.268	.369	.513	.378	1.000	.777(a)
Kaiser-Meyer-Olkin measure of sampling adequacy 0.830						
Barlett´s sphericity test			Aprox. Chi-squared			474.981
					df	10
					Sig.	.000

*measure sample adequacy

As can be seen in Table 5, the matrix presents acceptable correlations and the values of the sample adequacy measure exceed the recommended value of 0.5, so that the five dimensions that make up the 24 items proposed by Muñoz and Mato (2007) are statistically significant. In addition, the KMO value of 0.830, the Barttlet test of Sphericity test with a Chi² of 474.981 with 10 *df* and p-value 0.000 support the performance of the exploratory factor analysis. Subsequently, the percentage of explained variance is extracted, by the method of principal components with the criterion of values > 0.1 which is shown in Table 6, as well as the orthogonal rotation by the method of Varimax Normalization with Kaiser (Table 7).

Table 6. Total variance explained. Initial eigenvalues

Component	Total	% variance	% of accumulated
1	3.210	64.195	64.195
2	.805	16.098	80.292
3	.390	7.807	88.099
4	.307	6.145	94.244
5	.288	5.756	100.000

The value of the eigenvalue of 3,210 represents 64,195 % of the total variance extracted from the data matrix, which is grouped in the five dimensions of the scale.

Table 7. Rotated components matrix (a)

	Components				
Dimensions	1	2	3	4	5
ATRLMS	.962				
ATE		.875			
ATNMT			.880		
ATT				.843	
ATMPU					.842

Extraction method: analysis of main components. Rotation method: Varimax with Kaiser normalization. a Rotation has converged in 5 iterations.

The rotated matrix shows us the behavior of each component, where it is observed that anxiety towards real-life math situations (ATRLMS) was the one that presented the highest factor load, followed by anxiety towards evaluation (ATE), then anxiety towards numbers and math tasks (ATNMT), anxiety towards temporality (ATT) and finally anxiety towards math problems understanding (ATMPU). It should be noted that as a whole all the components presented significant loads > at 0.8, which justifies the purpose that was sought with the Varimax rotation, since the characteristic of this orthogonal rotation method is precisely the identification of the variables with the highest factorial loads.

To contrast the hypotheses on differences by gender, age and school grade, the ANOVA procedure is carried out, which provides the F statistic and its level of significance, for which the theoretical criterion is taken that indicates that if the significance intra-group is less than or equal to 0.05, the hypothesis of equality of means is rejected, otherwise if it is greater, equality of means is accepted (Tables 8a, 8b and 8c).

Table 8a. Age

Dimension		Sum of squares	*df*	Mean square	F	Sig.
ATMPU	Between groups	.058	1	.058	.150	.699
	Within groups	76.64	198	.387		
	Total	76.69	199			
ATT	Between groups	1.50	1	1.503	.087	.769
	Within groups	3429.89	198	17.323		
	Total	3431.39	199			
ATNMT	Between groups	1.93	1	1.934	.202	.654
	Within groups	1898.06	198	9.586		
	Total	1900.00	199			
ANSIESIT	Between groups	1.57	1	1.559	.177	.674
	Within groups	1741.99	198	8.798		
	Total	1743.55	199			
ATE	Between groups	3.53	1	3.532	.034	.853
	Within groups	20327.66	198	102.665		
	Total	20331.19	199			

Table 8b. Gender

Dimension		Sum of squares	*df*	Mean square	F	Sig.
ATMPU	Between groups	.915	1	.915	2.391	.124
	Within groups	75.779	198	.383		
	Total	76.694	199			
ATT	Between groups	81.149	1	81.149	4.796	.030
	Within groups	3350.246	198	16.920		
	Total	3431.395	199			
ATNMT	Between groups	74.672	1	74.672	8.100	.005
	Within groups	1825.328	198	9.219		
	Total	1900.000	199			
ANSIESIT	Between groups	.569	1	.569	.065	.800
	Within groups	1742.986	198	8.803		
	Total	1743.555	199			
ATE	Between groups	1304.765	1	1304.765	13.578	.000
	Within groups	19026.430	198	96.093		
	Total	20331.195	199			

Tabla 8c. Grade ANOVA

Dimension		Sum of squares	df	Mean square	F	Sig.
ATMPU	Between groups	.019	1	.019	.049	.825
	Within groups	76.675	198	.387		
	Total	76.694	199			
ATT	Between groups	1.116	1	1.116	.064	.800
	Within groups	3430.279	198	17.325		
	Total	3431.395	199			
ATNMT	Between groups	3.255	1	3.255	.340	.561
	Within groups	1896.745	198	9.580		
	Total	1900.000	199			
ANSIESIT	Between groups	.778	1	.778	.088	.767
	Within groups	1742.777	198	8.802		
	Total	1743.555	199			
ATE	Between groups	248.520	1	248.520	2.450	.119
	Within groups	20082.675	198	101.428		
	Total	20331.195	199			

The result shown in Tables 8a, 8b and 8c suggests the following: in Tables 8a and 8c called Age and Academic Grade, intra-group values higher than 0.05 are observed, which implies the existence of equality of means in the five dimensions of the scale. In the case of the gender variable, the significance values for the dimensions of ATT, ATNMT, and ATE are less than 0.05, so it is assumed that there is no equality of means, not so in the dimensions ATMPU and ATRLMS where there is equality in their means.

5. Discussion

The results of the research report very acceptable and concordant values with those obtained by Muñoz and Mato (2007), in terms of reliability and internal consistency of the scale, as well as the exploratory factor analysis. With the multivariate normality test of the data and the reliability of the scale, it was feasible to develop the exploratory factor analysis, which supports the result of our study, and which also presented acceptable values in terms of the correlation matrix and the Bartlett's test of Sphericity with Kaiser, with significance > 0.000 with n degrees of freedom.

Regarding the variance explained in the pilot test and in the final one, very significant factor loadings were found. For example, in the pilot test four factors explained 65.13 % of the variance, rising in the final test to 85.55 %, being this last one higher than that reported in this study (64.195 % Table 6).

In relation to the results on the possible differences with respect to gender, age and school grade, we report that there is no difference in the anxiety that students face towards the five dimensions of the scale based on age and school grade, However, differences were found based on gender in the dimensions of anxiety towards temporality, anxiety towards evaluation and anxiety towards numbers and math tasks.

The findings reported here, in which no differences were found in anxiety towards mathematics as a function of age and school grade, contrast with the studies by Wigfield and Meece (1988) and Ma and Kishor (1997) whose indicate that anxiety towards math tends to worsen with age. A possible explanation for this result could be due to the small age range of the participants in this research. 85.6 % are between 13 and 14 years of age.

Unlike, Reali, Jiménez-Leal, Maldonado-Carreño, Devine and Szücs (2016); Van Mier, Schleepen and Van der Berg (2019) and Devine, Fawcett, Szűcs et al. (2012), whose studies on anxiety towards mathematics did not identify a difference based on gender, in this study

differences in this sense were found in three of the five dimensions of the scale, which coincides with the findings reported by Villamizar, Araujo and Trujillo (2020) and Stanley, Nyarko and Frimpong (2021).

6. Conclusion

Mathematical anxiety is a phenomenon that is present in different activities carried out by human beings, and in a very particular way in the academic field. Students constitute a world population that has been the object of constant studies with the firm intention of understanding this phenomenon better every day. Of course, not all the world population has the same anxiety indices or indicators, much will depend on the context in which it is analyzed.

The study on the subject of mathematical anxiety that young people especially suffer when they face situations that are related to mathematics, such as homework or exams, is increasingly recurrent. This has led to an almost general concern of the academic authorities of public and private institutions in all countries, since this phenomenon has been characterized as an important problem that limits the success of the educational teaching-learning process.

From the results presented here, there is a concern for future research related to anxiety towards mathematics and differences based on gender. If different levels of anxiety between boys and girls could be presented in a larger sample of students in different contexts.

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