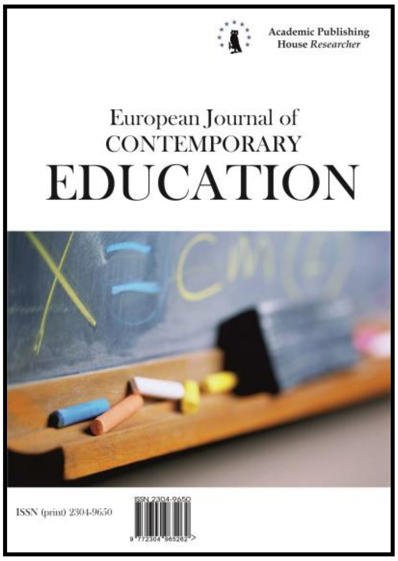
Published in the Slovak Republic
European Journal of Contemporary Education
E-ISSN 2305-6746
2018, 7(4): 741-753
DOI: 10.13187/ejced.2018.4.741
www.ejournal1.com



Among the Mathematics Tasks, Math Courses and Math Exams: How's the Level of Student Anxiety Toward Maths in a Private High School in Mexico?

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Abstract

The purpose of the study is to determine a latent structure of variables that explain the level of anxiety towards mathematics of high school students based on the interaction that the student has with the tasks, courses and math exams. For this purpose, the RMARS mathematical anxiety scale was used, which has a Likert-type scaling. The instrument was applied to a sample of 183 enrolled students from a private institution of upper secondary education located in Veracruz, Mexico and to obtain results, a factorial analysis was applied. The most significant finding is the obtained tetra-dimensional model, which contrasts with other models such as those of Alexander and Martray (1989) and recently with the penta-dimensional model of (Author 1 2017). This result suggests that the original design of the three-factor scale of Richardson and Suinn (1972), modified by Alexander and Martray (1989), does not apply to students in Latin contexts, such as the case of Mexico.

Keywords: anxiety, mathematics, higher secondary education, Mexico.

1. Introduction

Mathematics has been part of the formation of the human being, since childhood, mathematics contribute to develop a logical order that trains the mind to solve multiple problems of everyday life. Camarena (2014) explains that mathematics develops social skills and argumentative communication, reflective, analytical and critical attitudes, as well as ethical values of respect, responsibility and care for the environment, unfortunately in some cases the perception of it is different, causing people to experience symptoms of anxiety or stress towards it.

Since 1957, Dreger and Aiken introduce mathematical anxiety as a new line of research in which they define "the presence of a syndrome of emotional reactions towards arithmetic and

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mathematics". Subsequently, his work was aimed not only to study these reactions of anxiety but to design instruments to measure it. In 1968, Dutton and Blum contributed to the study of attitude towards mathematics and how to measure it by designing a survey that included several variables, such as anxiety of state traits, confidence, enjoyment and misconceptions. Years later, Suinn, Edie, Nicoletti and Spinelli (1972) designed the most used measure of mathematical anxiety in detection and as a measure before and after to evaluate the impact of interventions: the Mathematical Anxiety Rating Scale (MARS) There have been numerous efforts to assess the anxiety that mathematics arouses in certain people, although it is a very subjective phenomenon (Wood, 1988).

Currently, Pérez-Tyteca, Monje and Castro (2013) describe mathematical anxiety as an affective state characterized by the absence of comfort that an individual can experience in situations related to mathematics, both in their daily and academic life, and which manifests itself through a system of responses that encompass a series of symptoms, such as: tension, nervousness, worry, restlessness, irritability, impatience, confusion, fear and mental block.

The results obtained in the PISA test (OECD, 2015) indicate that regarding performance in mathematics, Mexico is below the average marked by the OECD (of 490 points). The result obtained by Mexicans was 408 points, similar to that of countries like Albania and Georgia. The 15-year-olds made a difference around 80 points below Portugal and Spain and between 10 and 15 points below Chile and Uruguay.

About anxiety, students in Mexico presented levels of anxiety above the average related to school work. 50 % expressed a lot of tension when they study (the OECD average is 37 %), and 79 % expressed concern about getting bad grades in class, a percentage higher than the 66 % average of the OECD countries. Figure 1 shows the results obtained related to anxiety.

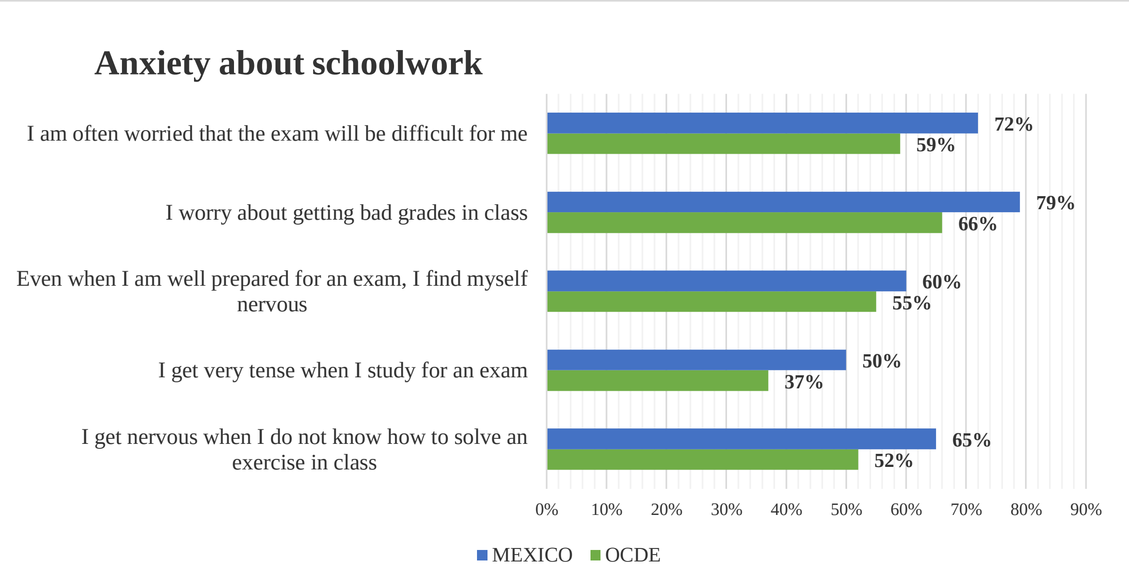

Fig. 1. Anxiety about schoolwork

Anxiety related to homework, courses or school exams is one of the main indicators of low satisfaction among students in Mexico. Anxiety is more frequent in schools where students study less than 50 hours per week, as revealed by OECD data in their Student Welfare report in 2015. Anxiety and low student satisfaction are a problem because in many cases they lead to students abandoning their studies to engage themselves in other activities, therefore, it is very important to identify certain anxiety-generating factors detected in students and work on them for the benefit of the new generations.

Taking as reference the construct of mathematical anxiety and considering the collateral effects that can affect school performance in high school students, the following questions are posed: What are the consequences of anxiety towards mathematics in student performance? Can this emotional problem be corrected? What alternatives or innovations can be implemented in study plans and methodologies to minimize anxiety in students?

Based on the arguments exposed previously, the following study question is raised: What is the latent structure of variables that explain the level of anxiety towards mathematics in high school students? Therefore, the main objective of the research will identify the structure of variables that explain anxiety toward mathematics

The hypotheses to be tested in this research are:

H1: There are latent structures of variables that explain the level of anxiety towards mathematics in high school students in a private school.

HO: There are not latent structures of variables that explain the level of anxiety towards mathematics in high school students in a private school.

For such effects, research is developed from the quantitative paradigm and its design and method are described in section 3.

2. Literature review

The literature related to anxiety towards mathematics has presented different approaches and perspectives over time. Lang (1968) quoted by Martínez, Inglés and García (2012) points out that anxiety manifests itself according to a triple system or three-dimensional factors which are cognitive, physiological and behavioral.

Hendel (1988) quoted by Agüero, Meza, Suárez and Schmidt (2017) specified that mathematical anxiety is related to general anxiety, anxiety towards exams and that produced by other academic subjects. Ashcraft (2002) defines mathematical anxiety as a "feeling of tension, apprehension or fear that interferes with mathematical performance". Ureña (2015) concludes that "mathematical anxiety is the manifestation of feelings such as tension, restlessness or terror that appear as a result of a bad relationship between mathematical knowledge and poor working memory to perform any numerical activity".

As a result of these studies, different measurement instruments have been created to identify the factors that generate anxiety in students when they are exposed to mathematical contents, as an example we have:

Fennema and Sherman (1976) designed a Likert-type scale to measure attitudes in the study of mathematics. The scale is made up of 108 items divided into nine factors that provide data related to: confidence in the learning of mathematics; success in learning mathematics; father's attitudes towards the study of mathematics; mother's attitudes towards the study of mathematics; teacher's attitudes towards the study of mathematics; mathematics as the domain of man; utility of mathematics and anxiety towards the study of mathematics; attitudes towards mathematics and motivation towards the study of mathematics.

The RMARS scale reviewed by Richardson and Suinn (1972) and modified by Alexander and Martray (1989) was designed to measure the mathematical anxiety presented by students. This measurement instrument is divided into 25 indicators, which are integrated into three dimensions, from item (1-15) the anxiety factor towards mathematics exams is analyzed, item (16-20) is aimed at determining the anxiety factor towards numerical tasks, and from item (21-25) the analysis of the anxiety factor of mathematics courses.

Muñoz and Mato (2007) developed an instrument to measure anxiety towards mathematics which showed a reliability coefficient of (α = .9504) with a structure of 24 Likert-type items, of which five factors can be identified that are related to the anxiety towards the evaluation, towards temporality, towards the understanding of mathematical problems, numbers and mathematical operations and mathematical situations of real life.

Subsequently García-Santillán, Edel and Escalera-Chávez, (2010) designed an instrument called EAPH-MF which is structured with 31 items based on a Likert scale, which aims to measure attitudes and perception towards financial mathematics through the variables history of mathematics, simulation and simulators, computer platforms and virtual learning communities.

On the other hand Pérez-Tyteca (2012) constructed a model of structural equations that helps to determine the constructs anxiety, self-analysis and utility in mathematics and on the other hand establishes causal relationships between them. In the following year, Pérez-Tyteca, Monje and Castro (2013) created a comic-based instrument which turned out to be a facilitating element when extracting information. Finally Eccius-Wellman and Lara-Barragan (2016) developed a questionnaire on mathematical anxiety, through this instrument it is possible to analyze attitudes, emotions and beliefs, using 20 items in a Likert-type scaling.

Measuring instruments were used to test anxiety in terms of certain socio-demographic elements; in the PISA test (OECD, 2015), it was found that the average boy exceeded the girls by seven points. Around 59 % of the girls and 54 % of the boys did not reach the minimum level of competence (Level 2) in mathematics marked by the OECD. On the other hand, based on the results obtained by Martínez-Artero and Nortes (2013), women have more anxiety than men through the scale Fennema and Sherman (1976). On the other hand, Delgado, Espinoza and Fonseca (2017) in their study of mathematical anxiety according to gender, found that men presented less mathematical anxiety than women, which is evident in the average score of men that was lower than the one obtained for the whole of the sample; while that of women was higher.

3. Design and Method

Design

This empirical research it's a non-experimental design because the independent variables are not manipulated to modify its effects. The study type is descriptive and exploratory cross-sectional. Considering that the study variables focus on the anxiety generated by the interaction of students of upper secondary level with mathematics in private schools, a correlational-explanatory study is carried out in order to find the set of underlying variables that explain this phenomenon.

Population

For the purposes of obtaining the data, from the total of the surveyed population, a non-probabilistic sample is used for convenience, from a private school, which is incorporated into the National Educational System. The school authorities allowed the researcher to apply a survey to a total of 183 high school students, of which (89) belong to first semester, (27) to the third semester and (67) to the fifth semester. This population belongs to Veracruz, located in the central area of the state with the same name. The condition of the survey was confidentiality of the school as well as the students surveyed.

The inclusion criteria considered that students were enrolled at the high school level in the first, third and fifth semester and that they had agreed to answer the test without obligation.

The particular characteristics of the sample identify 72 male students and 111 female students. 144 students live with both parents, 35 live alone with one of them and 4 live with another family member. Our key informants were the students themselves who were supervised by the teacher in turn and by the interviewer.

Instrument

Considering the measurement instruments discussed in the literature, the present study used a RMARS mathematical anxiety score scale from Richardson and Suinn (1972) which was modified by Alexander and Martray (1989), which measures the mathematical anxiety in students. (See Figure 2).

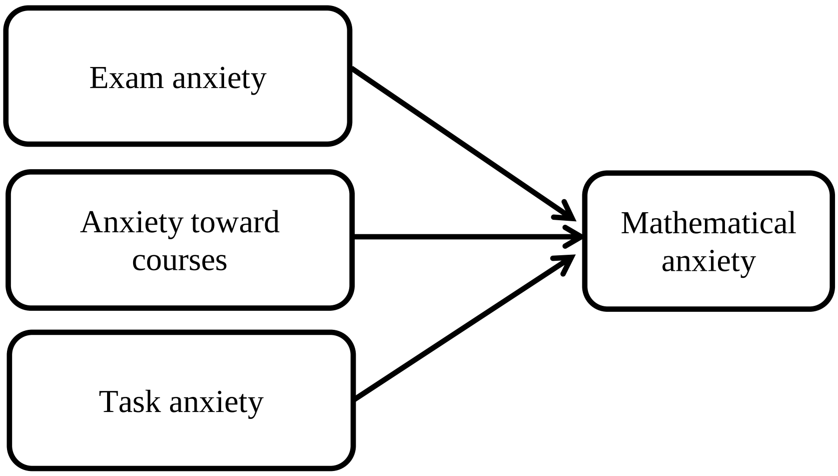

Fig. 2. Three-factor model of Richarson and Suinn (1972) take it of Navarro-Ibarra et al. (2017)

The RMARS scale is composed of two sections, the first section is aimed at identifying the socio-demographic profile of the interviewee and the second section is divided into 25 indicators that are integrated into three dimensions, which are described in Table 1.

Table 1. Structure of the instrument

VARIABLE	DIMENSION	INDICATOR
MATHEMATICAL ANXIETY	Exam Anxiety (Mathtest)	Item 1to 15
	Task Anxiety (Mathtask)	Item from 16 to 20
	Anxiety towards courses (Mathcourses)	Item del 21 al 25

Source: Navarro-Ibarra *et al.* (2017).

4. Analysis Procedure

For the analysis of the data to answer the research question, the statistical procedure of the Exploratory Factor Analysis (AFE) with extraction of main components is used, with the Varimax rotation method. In the first phase of analysis, the internal consistency of the data obtained in the field is assessed using the Cronbach's Alpha index, which according to García-Santillán, Rojas-Kramer, Moreno-García and Ramos-Hernández (2017) is defined as "the representation of the square of the coefficient of the correlation with which measures the consistency of the items using the average of all the correlations between all the questions".

Table 2. Reliability index

Concept	Cases	%	A	
Valid	183	100		
Excluded	0	0	α = .939	25 Items
Total	183	100		
Dimensions	MATHTEST MATHTASK MATHCOURSE		α = .837	3 dimensions

Fuente: own

Table 2 shows that the reliability of the Cronbach's Alpha data for all the items is α = .939 and for the grouped ones within the four dimensions it had an α = .837, taking Hair et al (1979) as reference for acceptable values of α> .80 and George and Mallery (2003) for an excellent α> .90 and for an acceptable α> .70, the high variability and internal consistency of the data can be confirmed, which makes viable and reliable instruments.

Exploratory Factor Analysis (AFE)

In order to identify the factors that generate anxiety in students when they are subjected to activities related to mathematics, an exploratory factor analysis is applied to determine the underlying structure of the data to analyze, which in addition to correlating them, may be reduced to factors and with this the variance of the phenomenon of study will be extracted (Bollen, 1989). The correlation matrix between the referred variables is shown in table 3 and 4 for the 25 items.

Table 3. Variables correlation

Variables	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}
X1	1.00	.46	.43	.50	.33	.33	.49	.62	.48	.50	.31	.43	.32
X2		1.00	.52	.51	.31	.28	.26	.37	.33	.28	.23	.35	.27
X3			1.00	.45	.37	.39	.34	.27	.27	.22	.35	.40	.37
X4				1.00	.34	.42	.38	.46	.47	.34	.37	.47	.25
X5					1.00	.43	.35	.37	.29	.39	.52	.28	.45
X6						1.00	.42	.31	.39	.26	.45	.42	.46
X7							1.00	.65	.50	.53	.36	.44	.41
X8								1.00	.67	.53	.27	.42	.28
X9									1.00	.33	.37	.47	.33
X10										1.00	.43	.35	.41
X11											1.00	.36	.52
X12												1.00	.44
X13													1.00

Source: own

Table 4. Variables correlation (continuation)

Variables	X_{14}	X_{15}	X_{16}	X_{17}	X_{18}	X_{19}	X_{20}	X_{21}	X_{22}	X_{23}	X_{24}	X_{25}
X14	1.00	.60	.43	.32	.35	.35	.48	.26	.56	.42	.59	.57
X15		1.00	.44	.42	.36	.33	.32	.23	.54	.37	.58	.42
X16			1.00	.62	.60	.54	.46	.34	.40	.30	.48	.45
X17				1.00	.81	.76	.64	.37	.51	.35	.55	.42
X18					1.00	.77	.66	.43	.51	.36	.52	.46
X19						1.00	.80	.36	.46	.33	.44	.39
X20							1.00	.38	.49	.39	.40	.42
X21								1.00	.41	.41	.32	.35
X22									1.00	.46	.69	.59
X23										1.00	.46	.33
X24											1.00	.64
X25												1.00

Source: own

As can be seen in Tables 3 and 4 that describe the correlation matrix, acceptable values are obtained among the 25 items that make up the instrument. The correlations show a positive behavior between them.

In addition, for this technique the test of the values of measurement of sample sufficiency per variable (MSA), the Bartlett test of Sphericity with Kaiser (KMO), whose result must be in a range of between (0 and 1) and finally, the value of the goodness-of-fit test X^2 are used.

Table 5. KMO & Bartlett Test of Sphericity

Measure sampling adequacy of Kaiser-Meyer-Olkin KMO		.906	MSA	
Bartlett test of Sphericity	Chi-square aprox	2754.533	(Mathtest), (Mathtask) (Mathcourses)	Range between: .835 a .958
	gl	300		
	Sig.	.000		

Source: Own

The results obtained in table 5 show that the sample adequacy in this analysis presents a very good adaptation in the data, since the index (KMO) yields a result of .906 close to unity, with a Bartlett test of Sphericity of X^2 (2754.533) with 300 degrees of freedom.

The significance analysis (Sig.) is perfect since the value .000 is obtained, so they are sufficient and appropriate to perform a factorial analysis. In addition, the values of MSA are in a range between .835 and .958 considering them acceptable. These values correspond to the measure of sampling adequacy. In this regard García-Santillán et al. (2017) explain that the MSA values must be greater than .5, so according to the results of tables 5 you can be in a position to reject the null hypothesis which refers to the non-existence of the set of latent variables since it cannot be explained by at least one factor.

Number of Factors to be extracted

To carry out the factorial analysis by means of the technique of main components that allows identifying the factors that exceed the theoretical threshold (> 1), we will base on the Kaiser criterion of Hair et al. (1979), which specifies that all components with a value greater than 1 should be considered. Table 6 shows the components obtained and their variance.

Table 6. Total variance explained and sedimentation graphic

Component	Self-value	% of variance	% accumulate
1	10.297	41.187	41.187
2	2.418	9.673	50.859
3	1.470	5.88	56.739
4	1.211	4.846	61.585

Source: own

Based on the results obtained described in Table 6, it can be observed that the analysis of the extraction yields four factors that comply with the theoretical hypothesis indicated by Hair et al. (1979) on the Kaiser criterion, which can be evaluated visually in the sedimentation graph of Figure 3.

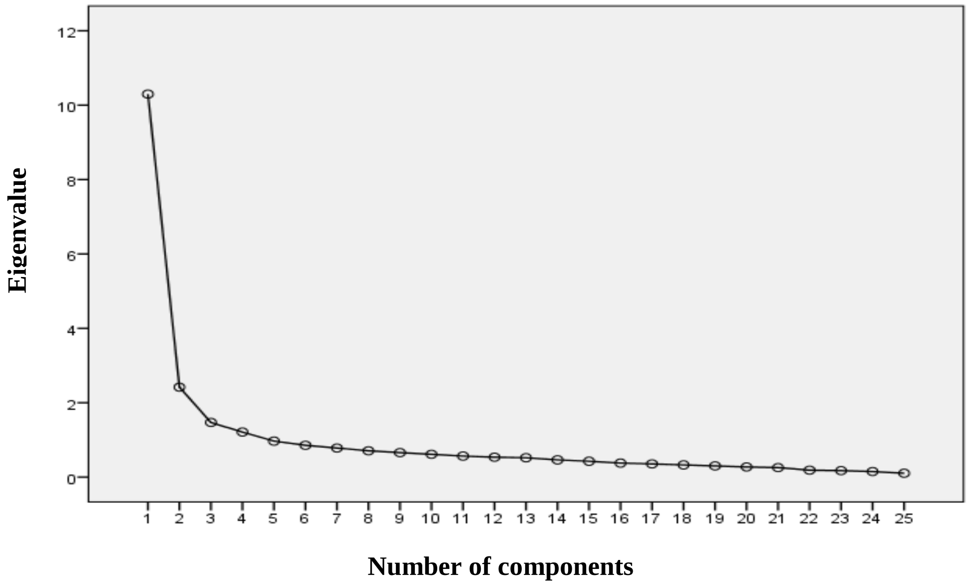

Fig. 3. Sedimentation graphic

Source: own

To determine the weight of each item of the instrument, it is necessary to determine the factorial weight of each of the test indicators of the test dimensions by means of the matrix of components, as well as its corresponding Communality (ψ), to obtain the Eigenvalue that represents the total of the assimilable variance obtained and that explains the phenomenon of study. For this reason, the rotated matrix of the extracted components is used, now individually by items. Table 7 shows the matrix of rotated components.

Table 7. Components matrix[a]

Variables	Component				Commonalities
	1	2	3	4	
X8	.800				.746
X9	.659				.577
X7	.645				.545
X10	.615				.559
X25	.611				.638
X15	.609				.587
X1	.598				.649
X14	.564				.601
X19		.889			.831
X18		.855			.808
X17		.844			.792
X20		.763			.691
X16		.619			.531
X24		.428			.662
X22		.419			.680
X11			.747		.648
X13			.662		.571
X5			.647		.562
X6			.588		.518
X21			.497		.422
X23			.411		.387

X3				.752	.712
X2				.719	.585
X4				.666	.604
X12				.501	.489
Eigenvalue	10.927	2.418	1.470	1.211	
% Variance	41.187%	9.673%	5.880%	4.846%	
% Total of variance			61.586		

Source:own

As shown in Table 7, the variables are grouped in the matrix of components according to the four factors obtained in the extraction analysis (Table 6), which are integrated by their indicators, the eigenvalue and the proportion of the variance Thus, in component 1, there are eight indicators that account for 41.187 % of the variance and an eigenvalue of 10.927; In the second component, seven indicators were grouped, explaining 9.673 % of the variance and an eigenvalue of 2.418; For the third and fourth component they integrate 6 and 4 indicators, which explain the 5.880 % and 4.846 % of the variance, with eigenvalue of 1.470 and 1.211 respectively.

In this way we obtain a total variance of 61.586 % that we can consider as acceptable to explain the study phenomenon, in the terms in which the objective was raised and which answers the research question.

5. Discussion

Based on the results derived from the analysis made of the data obtained from the surveyed population, which is within the sector of private higher education institutions in Veracruz, a resulting model was obtained in tetra-dimensional form, (see Figure 4), in contrast to the seminal studies of García-Santillán, Rojas-Kramer, Moreno-García, and Ramos-Hernández (2017) in which evidence was obtained of the existence of a penta-dimensional model in undergraduate students of the economic-administrative area at the Technological Institute of Veracruz by applying the RMARS scale of Alexander and Martray (1989).

The important finding is that the model of Alexander and Martray (1989), is a model of three factors, which contrasts with the model obtained in this study and with which it has been referenced previously penta-dimensional of (García-Santillán, 2017) .

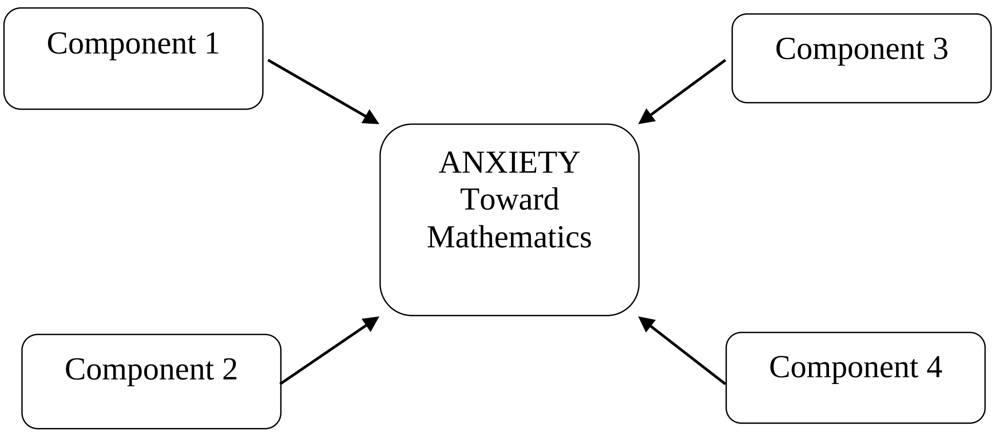

Fig. 4. Four-dimensional anxiety model

Table 8 shows each of these components, both the factorial weight they contribute to their self-value, and the textual definition of the meaning of each of them, the latter from the translation made to each item of Richardson and Suinn's original scale (1972) and that was modified by Alexander and Martray (1989).

Table 8. Matrix of extracted components

Component 1 "Anxiety when preparing for a Mathematics test"	Component 2 "Anxiety when solving math problems"	Component 3 "Anxiety towards Mathematics Books"	Component 4 "Anxiety when presenting an exam in a Mathematics course"
X8.- Think about the next math exam a day before (.80)	X19.- Have a series of problems with multiplications to solve (.889)	X11.- Grab a math book to start a difficult task that implies the reading of mathematical theory (.747)	X3.- Presenting a quiz in a mathematics course (.752)
X9.- Think about the next math exam one hour before (.659)	X18.- Have a series of problems with subtractions dictated to solve (.855)	X13.- Open a math or physics book and see a page full of problems (.662)	X2.- Present the math section of an institutional exam (.719)
X7.- Think about the next math exam a week before (.645)	X17.- Have a series of numbers dictated to add on paper (.844)	X5.- Grab a math book to start a task (.647)	X4.- Present a final exam in a math course (.666)
X10.- Realize that you have to take math the 3 years of junior high school and high school (.615)	X20.- Have a series of problems dictated with divisions to solve (.763)	X6.- Have a task assigned with many difficult problems to be handed in next class (.588)	X12.- Receive the final math grade by mail (.501)
X25.- Enter the mathematics class (.611)	X16.- Do mental calculation (.619)	X21.- Buy a math textbook (.497)	
X15.- The moment they give you an exam in math class (.609)	X24.- Listen to another student explaining a mathematical formula to someone else (.428)	X23.- Enroll in a mathematics course (.411)	
X1.- Study for a math exam (.598)	X22.- Observe a teacher solving an algebraic equation on the board (.419)		
X14.- Study for the math exam (.564)			

Source: own

If we consider the model shown in figure 4, as each component indicator (Table 8) it is possible to introduce four-dimensional model obtained in this research (Figure 5).

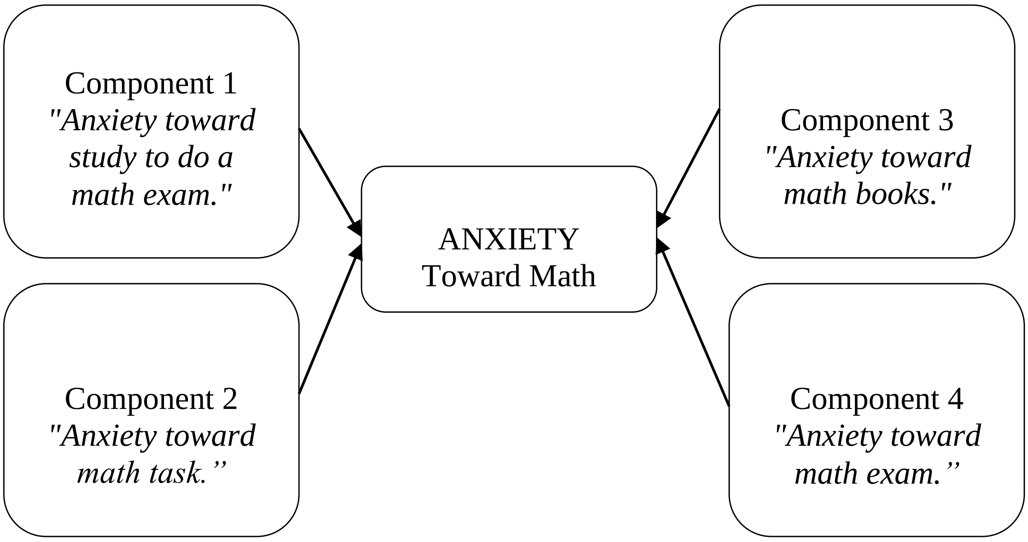

Fig. 5. Conceptual model of anxiety

It is important to highlight another finding obtained in this study, which is that items from the RMARS scale of Alexander & Martray (1989) were not excluded, although the order of them was modified and regrouped in different dimensions. This data is relevant if we consider that in other studies in Latin contexts, such as the one of García-Santillán et al. (2017) the indicators were excluded: Item 6, Item 7, Item 12, Item 13, Item 22, Item 23 and Item 25.

The results of this research contribute to design and implement new strategies in the teaching-learning processes that contribute to the reduction of anxiety levels in the students who were the object of this study.

While it is true, when scales are applied in different contexts that have been designed to measure this phenomenon, it is common that they present different behavior, probably derived from the translation of the original language to the context in which they will be applied.

The psychometric properties of the scales that measure the anxiety towards mathematics, have given significant evidence that has allowed to improve in this aspect, that is to say, the study plans have been modified and new teaching tools have been implemented that integrate new evaluation criteria for the learning process.

These finding remains on the table of discourse, considering that the methodology followed at all times the procedure that other recent studies have developed that have sought to explain the same anxiety phenomenon (García-Santillán et al., 2010, García-Santillán et al., 2017, Navarro-Ibarra, 2017).

Finally, it is worth noting that anxiety towards math exams, the resolution of mathematical problems, when resorting to the reading of a math book and to mathematics courses, may not be so surprising for the subject scholars, which may be interesting for future research as they have suggested in other studies, it is the monitoring that is given to these student populations, that is, how they have been evolving and what their behavior will be in the future, for example, when they enter professional education in different universities in the country.

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