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Anxiety towards mathematics on undergraduates in a Nautical School (An empirical study in Port Veracruz)

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ABSTRACT

The following study aims to measure the level of anxiety towards mathematics on students of a nautical school in Veracruz and for that purpose, it is founded on the seminal work of Fennema and Sherman (1976) and the recent studies of García-Santillán, Escalera and Venegas (2013, 2014, 2015). To achieve this end, the instrument used was the scale of Muñoz and Mato (2007), which measures five factors: anxiety towards evaluation, temporality, numbers and maths operations, understanding of maths problems and mathematical situations in daily life. The poll was applied face to face to 202 students of different academic years of the Fernando Siliceo nautical school in the city of Veracruz. The internal consistency was α=0.947 individual and 0.776 grouped (Hair et. al, 1991). This study was approached from a transversal non-experimental quantitative paradigm using an explorative factorial analysis as data-gathering technique (KMO, X^2, α=0.05).

KEYWORDS
Anxiety towards mathematics, mathematics abilities, evaluation towards mathematics, temporality towards mathematics, mathematical situations

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Introduction

Education is a topic that has always been given a lot of attention as it is considered to be one of the pillars of society. It is the basis needed on a personal level as well as on a more global perspective in being the element contributing to the growth of a country and being the key for a promising future.

Mathematics play a crucial role in education as it is a knowledge branch used in daily life situations regarding finances while being present in an increasing amount of jobs related to engineering, technology, design and animation, to name some of the most popular ones.

However, despite its relevance, Mexico has great limitations in this area, as it is shown through the results provided by the Organization for Economic

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Cooperation and Development (OECD) in their 2012 PISA (Program for International Student Assessment) study. Said report states that although Mexico had been able to increase its ratio in mathematics by 28 points in comparison with the 2003 study, 55% of Mexican students still failed to achieve the level of basic math competence with an average score of 413, placing the country below others such as Portugal (487), Spain (484) and Chile (423); it should be noted that the OECD is 494, which implies that Mexico is nearly two years of schooling below that average.

It is therefore most likely to assume that it would take more than 25 years to reach the minimum average score of the OECD in the field of Mathematics. One of the reasons for that could relate to the level of anxiety to it, since in the mentioned report it was found that 75% of students show concern to the subject, especially women and it is in Mexico where the highest level of anxiety in the OECD can be found.

Therefore, to what extend could anxiety be the cause of such a low performance in mathematics? Which are the factors that affect the obtainment of such low results in this subject? Or could it be due to the teaching capacities of the professors? Whatever the reasons may be, it seems adequate to do a research study in order to gain empirical evidence of this phenomenon and to help explain students' lag. In order to measure anxiety towards mathematics Fennema and Sherman (1976) made seminal studies proposing a scale of 108 factors corresponding to nine categories. They discovered confidence to be highly associated to performance as cognitive variables.

On the other side Tapia and Marsh (2004) developed a test called Attitude Towards Mathematics Inventory (ATMI) consisting of 49 items related to the categories of confidence, usefulness, motivation and expectations of parents and teachers, to mention some examples; these authors found that if the level of enjoyment in students rises, their level of anxiety towards mathematics decreases.

In addition to this, it is pertinent to mention that there have been recent studies confirming a close relation between anxiety towards mathematics and other subjects related to statistics and the performance of students in different school levels. Such has been the case with the studies made by García-Santillán in collaboration with other authors in the last few years (2014 and 2015), who have used the scale of Muñoz and Mato (2007) in different academic contests. They were able to provide the relationship among variables of this instrument effectively and to confirm that anxiety is a factor that hinders the learning process of mathematics and that attitude towards mathematics is related to the performance in such matter, being anxiety towards evaluation a variable that has significant importance in anxiety towards mathematics.

In the particular case of this research, the central question is the following: is there a structure of latent variables that can explain the level of anxiety toward mathematics in the college students of the nautical school Fernando Siliceo? And the aim is to identify this structure of latent variables that explain the level of anxiety toward mathematics in the college students to gain a better understanding of the studied phenomenon.

Also, the following hypotheses are proposed:

H_o: There is no structure of latent variables able to explain the level of anxiety toward mathematics in college students.

H_a: There is a structure of latent variables that explain the level of anxiety toward mathematics in college students.

And specifically:

H_i: Anxiety toward mathematics in the college students can be explained at least by one factor.

Next, the relevant literature that explains this anxiety phenomenon is analyzed and discussed, allowing us to situate ourselves in the theoretical and empirical reality that sustains the present research.

Literature review

Firstly, the concept of anxiety towards mathematics can be defined according to Richardson and Suinn (1972) as "the feelings of tension and anxiety that interfere with the manipulation of numbers and the resolution of mathematical problems in academic and daily life situations" (p. 1). These same authors also developed the Mathematics Anxiety Rating Scale (MARS) and established in their research the reliability and validity of this instrument.

A few years later, Tobias and Weissbrod (1980) described anxiety towards mathematics as "the panic, helplessness, paralysis and mental disorganization that arises among some people when they are required to solve a mathematical problem" (p. 65). In their research they found differences in the mathematics performance among men and women due to anxiety towards this subject.

As a consequence, one could assume anxiety towards mathematics to be mainly considered as a factor preventing the students from achieving a good learning performance. This was clearly demonstrated by the studies of Luo, Wang & Luo (2009), Venkatesh Kumar & Karimi (2010), Díaz, Herrera, Saucedo & Recio (2015) and García-Santillán, Escalera-Chávez, Moreno-García & Santana-Villegas (2015), who also found higher anxiety levels in women than in men. However, it is important to mention that an evaluative research with transversal design made to the students of the Bachelor Degree in Management of the Universidad Autonoma del Estado de Mexico proved that moderate doses of anxiety could lead to high performance in mathematics (Petriz, Barona, López, & Quiroz, 2010) in which case a low level of anxiety does not necessary cause a high performance in this subject.

Other studies probe that there are certain variables that impact the anxiety towards mathematics, such as the one of Pérez-Tyteca, Castro, Segovia, Castro, Fernández & Cano (2009) whom by Based on a statistic-descriptive data analysis using the scale from Fennema- and Sherman (1976), the latter found that in addition to the gender also the branch of knowledge that the respondents students were studying is an important element to consider.

Thanks to a correlational research using the Mathematics Anxiety Rating Scale (MARS) and a NEO five-factor personality test, Heydari, Abdi & Rostami (2013) demonstrated that teacher personality characteristics affect the anxiety towards mathematics. In line with that for example a conscientious, nice, responsible teacher with high flexibility and emotional stability may be very useful to reduce the anxiety levels among students.

An additional example of an external variable related to the study object is presented by Tapia & Marsh (2004), who developed the ATMI scale (Attitude towards Mathematic Inventory) including factors of anxiety, confidence, value, appreciation, motivation and expectations from parents and teachers. They discovered that at least in the sample they took, the attitude towards mathematics of parents and teachers did not affect the individuals, suggesting that this case should be analyzed with a more representative sample or be checked on whether there may be variation depending on the people´s age.

On the other hand, the results of Estrada & Díez-Palomar (2011) show a bond with the self-concept, meaning the confidence or insecurity towards mathematics and the attitude that one has to the subject; thus, being able to solve a math problem causes a positive attitude that comes from that achievement. These authors created an own scale from the 1995 Survey of Attitudes Toward Statistics (SATS) and complemented the questionnaire with questions related to profession, gender, age, number of kids and education level, in order to better know the profile of the participants.

In the survey made to teachers by Çatlıoğlu, Gürbüz & Birgin (2014), the data were analyzed by the SPSS (Statistical Procedures for Social Science) program. This helped to find out that although attitudes and perceptions to mathematics affect the anxiety levels towards the subject, variables such as the education level of the parents, family income and place of birth turned out to be not relevant, hence proving that some variables a researcher may consider for the analysis are inconsequential.

Transversal studies with correlational scope conducted in a purely academic context by some of Mexico´s renown colleges such as Universidad Nacional Autónoma de México (UNAM), Instituto Politécnico Nacional (IPN) and Escuela Bancaria y Comercial (EBC), showed that students from a Management Postgraduate Course, even when they had several years of experience in the workplace, also showed insecurity and anxiety to situations related to the use of mathematics (Cardoso, Cerecedo, & Ramos, 2012).

In a factor analysis study, García-Santillán, Edwards-Wurzinger & Tejada-Peña (2015) proved that with the use of the Muñoz & Mato (2007) scale, all the evaluated factors are directly associated, for instance, if there is anxiety towards evaluation, there is also anxiety towards the understanding of mathematical problems, towards numbers and towards mathematical situations in daily life.

In an academic paper, Furner & Bernan (2003) recommended students to consider mathematics as they cannot avoid.

Based on their correlation analysis, Muñoz & Mato (2008) concluded in their paper that developing certain attitudes is an implicit part of the teaching objectives and therefore has to be an education aim. According to them the results of researches about attitude towards mathematics should be used to improve the student´s learning process by focusing on the comprehensive (holistic?) training of the person.

Tezer & Bozkurt (2015) made a recent study using parameters such as the anxiety towards mathematics scale developed by Ikegulu in 1998 and the 1990 attitude towards mathematics scale of Baykul in order to evaluate the levels of anxiety and attitude towards mathematics of a group of students in need of protection. According to them, a positive teaching and learning atmosphere can

help students to learn mathematics with pleasure. It is therefore important to know the causes of anxiety towards mathematics and to remove them from educational practice.

As a result of these findings, this study aims to investigate the phenomenon of mathematics anxiety describing in a first step the methodological design as well as the analysis and results of the present research. After that, also conclusions are discussed and some recommendations and future lines of research are stated, thus increasing the knowledge regarding this matter and using it to improve mathematics educational processes, which is very useful in the students' personal and academic training.

Methodological design

In order to answer the research question and the corresponding hypothesis contrasting, besides achieving the proposed objective, it is appropriate to outline the research design and to describe the methods used.

The study is not-experimental thus not working on the independent variable, which is why a cross-sectional type was applied by conducting the field research during the week of January 11th to the 15th, 2015. Also, the research is explanatory, since the measure of the anxiety levels is required and the data analyzed and interpreted.

The scale of Muñoz & Mato (2007) called "Anxiety towards Mathematics Test" is replicated in the field research, allowing the identification of the relevance of the studied variables and their possible correlation to explain the anxiety of students toward mathematics. This methodological instrument measures five factors: Anxiety towards evaluation (ANSIEVAL), Anxiety towards temporality (ANSIETEM), Anxiety towards the comprehension of mathematical problems (ANSIECOM), Anxiety towards numbers and mathematical operations (ANSIENUM) and Anxiety towards mathematical situations in daily life (ANSIESIT). The test was applied to 202 students enrolled in their 1° and 2° years of college, thus composing the sample taken from a population of 743 students registered in the school cycle 2015-2016 of the nautical school Fernando Siliceo in the city of Veracruz.

Sample inclusion criteria included: -Registered students who have not failed previous course subjects.

-Mexican nationals

-Students enrolled in the 1° and 2° years of college.

-Students who answered the entire survey.

For the contrasting of hypothesis, we followed the statistical procedure proposed by García-Santillán et al. (2013, 2014, 2015) using the exploratory factor analysis to reduce the group of factors in the study. This included in particular:

a) The statistical test is X_n^2 and the Bartlett´s test of Sphericity KMO (Kaiser-Meyer-Olkin) with a significance level = 0.05 and n freedom degrees.

b) Calculate the anti-image matrix to get the Measure Sample Adequacy (MSA) for every variable, which should approximate to 1.00 and hence, values lower than 0.5 should be excluded.

c) Calculate the correlations matrix to identify the value of the determinant, which should be close to 0.00, considering that values close to 0 provide evidence of high correlations, while correlations are low if the value of the determinant is closer to 1.d) Calculate the factors and communalities, as well as Eigenvalues (EGV) that will show the total variance.

d) Finally, determine the range of acceptance or rejection of the hypothesis:

-Reject H_0 if $X^2_{n_{Calculated}} > X^2_n$.

Data analysis

The gathered data were analyzed using the Statistics Data Editor SPSS software (version 19), providing the following results:

Firstly, the reliability of the data was verified by applying the Cronbach alpha coefficient, which measures the correlations among the items of the instrument and whose minimum acceptable value is 0.70 (Oviedo & Campo-Arias, 2005), since the closer to 1 the result is, the more reliable the scale is. In the present case, both the alpha coefficients of 0.947 (extended) and 0.776 (grouped) are quite acceptable and hence it is possible to confirm the high validity of the test.

Table 1. Statistical reliability Cronbach's alpha (α)

ANSIEVAL, ANSIETEM ANSIECOM, ANSIENUM, ANSIESIT		Individual	Accumulated
Number of cases	202	0.947	0.776
	%		
		100%	100%
Excluded cases		0	0
%		0.0%	0.0%
Total Items		24 ítems	5 ítems

Source: own

Within this order of ideas, we can now describe its mean and its standard deviation in order to determine the coefficient's variation and make it possible to identify the variables with the most variation with respect to others. Therefore, the descriptive statistics and the variation coefficient of each of the analyzed dimensions are presented in Table 2.

Table 2. Descriptive statistics

	Mean	Typical deviation	Number of analysis	CV = DVμ
ANSIEVAL	27.4703	9.11953	202	33.19%
ANSIETEM	9.8366	3.89770	202	39.62%
ANSIECOM	5.3614	2.36960	202	44.19%
ANSIENUM	5.9406	2.52085	202	42.43%
ANSIESIT	4.0050	1.40892	202	35.17%

Source: own

Based on the results described in Table 2, it can be seen that the variable ANSIECOM and ANSIENUM (44.19% and 42.43%) is the largest compared to the rest of the variables that show similar behaviour.

Continuing with the calculus, and in order to validate whether the statistical technique of factor analysis can explain the phenomena studied. Firstly, we carry out the test of Sphericity with KMO and goodness of fit index X^2 with significance α=0.01 and Measure Sample Adequacy (MSA). We remember that KMO & Bartlett's Test of Sphericity is a measure of sampling adequacy that is recommended to determine whether there is a correlation between the variables studied and whether the factor analysis technique should be used in this case. KMO & Bartlett's test plays an important role for accepting the sample adequacy.

Therefore, in order to find internal consistency, the Bartlett´s test of Sphericity with Kaiser-Meyer-Olkin KMO was applied and the result was 0.812, showing the variables correlation by achieving an acceptable range (> 0.5). Also, X_n^2 Pearson test was used with significance ($p < 0.01$). It can be noted that the obtained values were high, 735.128 with 10 degrees of freedom.

Furthermore, the Bartlett's Test of Sphericity relates to the significance of the study and thereby shows the validity and suitability of the responses collected to the problem being addressed through the study. Table 3 shows the results.

Table 3. KMO and Bartlett test of Sphericity

Measure sampling adequacy Kaiser-Meyer-Olkin.		0.812
Bartlett's test of Sphericity	Chi-squared approximated	735.128
	df	10
	Sig.	0.000

Source: own

Table 4 shows the correlation values of the analyzed dimensions. As it can be seen that all their levels are high (> 0.05), they are all related and there is a consistency among the set of variables proving the adequacy of Factor Analysis. The obtained value of the determinant (0.025), which is less than 0.05, gives further evidence that there are significant correlations in the set of the studied variables.

Table 4. Correlation Matrix

Correlatio	ANSIEVAL	ANSIETEM	ANSIECOM	ANSIENUM	ANSIESIT
ANSIEVAL	1.000				
ANSIETEM	.808	1.000			
ANSIECOM	.715	.703	1.000		
ANSIENUM	.750	.698	.822	1.000	
ANSIESIT	.493	.365	.606	.525	1.000

a. Determinant = .025
Source: own

In the diagonal of the correlation anti-image matrix from Table 5, it is possible to see the Measure of Sample Adequacy (MSA) for each dimension, which must have a value closer to 1 to determine whether the Factor Analysis is pertinent for the explanation of the gathered data. We remember that Henry

Kaiser (1970, 1974) introduced a Measure of Sampling Adequacy (MSA) of factor analytic data matrices. After was modified by Kaiser and Rice (1974). This is just a function of the squared elements of the 'image' matrix compared to the squares of the original correlations. The results range from 0.790 to 0.842, which is significant and therefore confirms that the Factor Analysis is optimal to explain the phenomenon of mathematics anxiety.

Table 5. Anti-image Matrix

Anti-image matrix						
Variables		ANSIEVAL	ANSIETEM	ANSIECOM	ANSIENUM	ANSIESIT
Anti-image correlation	ANSIEVAL	**.809**[a]				
	ANSIETEM	-.584	**.790**[a]			
	ANSIECOM	-.010	-.271	**.805**[a]		
	ANSIENUM	-.285	-.071	-.536	**.842**[a]	
	ANSIESIT	-.03	.223	-.370	-.033	**.817**[a]
	a.*MSA*					

Source: own

The overall MSA as well as estimates for each item are found. Thus, the correlation coefficients anti-image that appear in diagonal range from 0.815a to 0.919a are significant, and it is confirmed that factor analysis it is optimal to explain the phenomenon studied.

Next, the factor and components will be examined as shown in Table 6, the Components Matrix, where the five studied dimensions and communalities as well as de Eigenvalues can explain the total variance. It is important to mention that by adding the square value of each factor we get 3.626 as Eigenvalue.

Table 6. Components Matrix, Communalities, Eigenvalue and total Variance

	Component 1	Communalities
ANSIEVAL	0.894	0.800
ANSIETEM	0.853	0.727
ANSIECOM	0.910	0.828
ANSIENUM	0.902	0.814
ANSIESIT	0.677	0.458
Eigenvalue	3.626	
Varianza Total	0.7252 = 72.52%	

Source: own

Finally, we have the total Variance data explained in Table 7, since in Table 6 the Variance obtained was 72.52%, it means that if the Eigenvalue is more than 1 (3.626), the existence of a component that explains such Variance is proved. Also in figure 1 we may see one component greater than 1.

Component 1 shows in the data that each of the dimensions has a factorial weight >0.5, being ANSIECOM (anxiety towards the comprehension of mathematical problems) the one with more weight (0.910), followed closely by ANSIENUM (anxiety towards numbers and mathematical operations) with 0.902.

The ones with lesser but still significant factorial weight are ANSIEVAL (anxiety towards evaluation) with 0.894 and ANSIETEM (anxiety towards

temporality), while the lowest value is ANSIESIT (anxiety towards mathematical situations in daily life) with a value of 0.677.

Table 7. Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.627	72.538	72.538	3.627	72.538	72.538
2	.694	13.877	86.415			
3	.329	6.589	93.004			
4	.204	4.088	97.092			
5	.145	2.908	100.000			

Extraction method: Main Component Analysis
Source: own

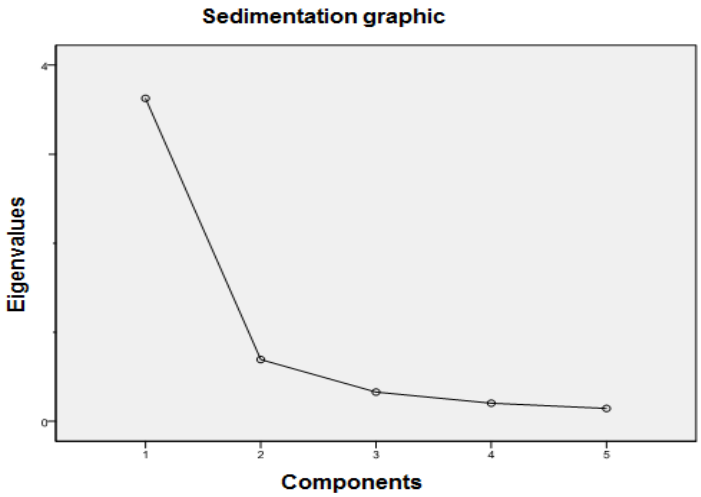

Figure 1. Component graphic

Conclusion

Anxiety towards mathematics is one of the barriers that students face during their school life, which directly affects their academic performance. Furthermore, this subject is of vital importance in the professional and academic development of the students, specifically to the sample of this study, since throughout their career, most of the subjects are related to it (algebra, statistic, and dynamics, to mention some examples).

In the college chosen for this research, students present high levels of anxiety towards mathematics, which according to Cardoso et al. (2012) can be inferred from their experiences in former academic training, so that despite having studied mathematics for several years, they show insecurity and anxiety towards the subject in the present course.

Moreover, it is possible to observe that factor analysis turned out to be a viable technique in the processing of information and proved the pertinence of the studied dimensions related to the anxiety of students towards mathematics, proving a correlation between variables.

As in García-Santillán et al. (2015), the present results show that anxiety towards mathematical situations in daily life is the dimension with less weight in the phenomenon, contributing only to a 45.8% of the variance, so that students show little anxiety to it.

The former could imply that students have a higher level of anxiety in the academic context while their anxiety noticeably decreases when facing daily life situations where mathematic knowledge is required. This is interesting because, as Furner and Berman (2003) stated, students must realize that mathematics can be applied outside a classroom and are needed in daily life, which could help improve their perception towards the subject and reduce their anxiety level by considering it a necessary part of society and not only a demand in school context.

On the other hand, anxiety towards the comprehension of mathematical problems and towards numbers and mathematical operations are the components that have more saturation (0.910 y 0.902 respectively) and contribute in a 82.8% and 81.4% to the variance, even though the remaining categories, anxiety towards evaluation and temporality got high percentages (80% y 72.7%), implying that most dimensions significantly affect the anxiety of students towards mathematics.

The information obtained from this research is pertinent since anxiety towards mathematics is a factor that prevents the students´ development and reduces their performance, not only in this subject but in others, which may lead to failure in their careers and to hinder students from finishing their degree.

One limitation of this study lies in the size of the sample, because it is appropriate to conduct studies with larger samples that allow us to identify which of the factors is the most recurrent. In future research it is recommended to conduct studies to other areas of the social sciences schools.

Recommendations and future lines of research

Studies regarding this matter are of great importance in order to discover which variables have an effect in anxiety towards mathematics in different academic contexts, such as private and public education and throughout the school levels. The findings can be used to take steps to decrease these variables which will in turn enhance the performance of the students in mathematics.

Organizations offer another environment where anxiety towards mathematics is present and studies carried out in such areas may show the correlations between anxiety towards mathematics and the job performance of employees in all positions and levels of the company. Considering the information available, it is possible to assume that not only study programs should be taken into account to improve the academic performance of the students but also psychological and emotional elements.

Another proposal could be to approach how the levels of anxiety towards mathematics impact other subjects where mathematical concepts and operations are needed. Furthermore, there are other aspects that have an effect on anxiety towards mathematics and which are external from the academic elements, for instance, the context and work environment of the mathematics professors and it is necessary to find if these elements affect the level of anxiety in the students for the purpose of developing strategies to reduce it.

A positive attitude towards mathematics can be achieved if the person likes the subject because then the learning process is viewed as enjoyable and not as an obligation, therefore, if the causes of anxiety towards mathematics are removed, a pleasant atmosphere will be present in the classroom (Tezer & Bozkurt, 2015)..

Disclosure statement

No potential conflict of interest was reported by the authors.

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