

Mathematics Anxiety in College Students in Costa Rica and their Relationship with Academic Achievement and Socio-Demographic Variables

Ansiedad matemática en estudiantes universitarios de Costa Rica y su relación con el rendimiento académico y variables sociodemográficas

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Summary

The study tried to determine the relationship between mathematics anxiety and the variables of gender, academic achievement, number of times students have taken the course and type of school in students taking the course MAT-001 General Mathematics of the National University of Costa Rica. To that end, a purposive sample of 472 students of such course was collected and the instrument of Hopko, Mahadevan, Bare and Hunt was adjusted to it (2003). Data collected were analyzed with the statistical program SPSS applying the corresponding hypothesis tests. According with the results, students showed a medium level of math anxiety and women showed a math anxiety significantly higher than men, while student graduated from private schools showed a significantly lower level of math anxiety than those from public schools or from the modality “General Equivalency Diploma”. Besides, the higher the math anxiety of the student is, the lower their academic achievement will be. Finally, there were no statistically significant differences between math anxiety and the number of times students have taken the course.

Keywords: Mathematics anxiety, college students, academic achievement, socio-demographic variables

Resumen

El estudio buscó determinar la relación entre ansiedad matemática y las variables género, rendimiento académico, cantidad de veces que ha llevado el curso y tipo de colegio, en estudiantes del curso MAT-001 Matemática General de la Universidad Nacional de Costa Rica. Para ello se escogió una muestra intencional de 472 alumnos de dicho curso y se les aplicó una adecuación del instrumento de Hopko, Mahadevan, Bare y Hunt (2003). Los datos recolectados fueron analizados con el programa estadístico SPSS aplicando las pruebas de hipótesis correspondientes. De acuerdo con los resultados, se encontró que los estudiantes presentaron un nivel medio de ansiedad Matemática y que las mujeres mostraron una ansiedad matemática significativamente mayor que los hombres; mientras que los estudiantes

egresados de colegios privados obtuvieron una ansiedad matemática significativamente menor que los provenientes de colegios públicos o de la modalidad de “bachillerato por madurez”. De igual forma resultó que entre mayor es la ansiedad matemática del estudiante su rendimiento académico será significativamente menor. Por último, no se encontraron diferencias estadísticamente significativas entre la ansiedad matemática y la cantidad de veces que el estudiante ha llevado el curso.

Palabras clave: ansiedad matemática; estudiantes universitarios; rendimiento académico; variables sociodemográficas.

Introduction

Learning mathematics is increasingly important, as stated by the National Council of Teachers of Mathematics (NCTM, 2003) since “in this changing world, those people who understand and can do and use math will have more opportunities and options to determine their future.” (p.5)

However, students constantly say, “I do not like math”, “math is very difficult”, “math makes me feel nervous and worried”, “I want to study a degree that does not include math”, among others. These references may be symptoms of what some experts call math anxiety. Marshall (2000) says that math anxiety “is an important, but less understood reality by students and an aspect poorly addressed by some teachers” (p. 108).

Pérez-Tyteca and Castro (2011) also refer to this behavior and describe it as an affective state characterized by the lack of comfort, symptoms of which are tension, nerves, concern, worry, irritability, impatience, confusion, fear and mental block.

This topic has been of interest to the community of researchers for more than 40 years, and it is still a very relevant topic. As proof of this, it was incorporated in the PISA test 2003 implemented in 40 countries and its results show that a large number of 15-year-old students who participated in the test showed math anxiety (Pérez-Tyteca, 2012).

Moreover, the affective domain has been recognized and highlighted as a very important aspect in mathematics teaching and learning process, so that some authors state that it is necessary to reduce the students’ fear of math before teaching it (Guerrero, Blanco & Castro, 2001; Pérez-Tyteca & Castro, 2011; Pérez-Tyteca, Castro, Rico & Castro, 2011; Quiles, 1993).

Besides, Manay (2009, as cited in Lamas, 2015) states that there is a significant relationship between anxiety and academic achievement. In this regard, some authors state that math anxiety has effects on students’ academic achievement (Gil, Blanco & Guerrero, 2005; Mato & Muñoz, 2010; Pérez-Tyteca & Castro, 2011; Manay, 2009; as cited in Lamas, 2015),

since high math anxiety is related to a low academic achievement and vice versa. (Aiken, 1970; Reyes, 1984)

It has been observed that math anxiety can influence the student's degree choice, since a low academic achievement in math can limit them to choose degrees in which the syllabus contains smaller number of math courses (Pérez-Tyteca & Castro, 2011).

This behavior also affects the student's behavior when working with math content, since an excessive anxiety reduces student's energy and attention to cognitive activities (Alegre, 2013). In addition, students who have a high level of anxiety prefer to do math tasks as quickly as possible, forgetting about doing them carefully (Hackett, 1985). According to Ashcraft and Krause (2007), they perform them in order to reduce pressure time.

When taking into account that college students show mostly math anxiety (Gavira, 2008) and that it has negative effects on the academic achievement and the general behavior of the student when dealing with math tasks, it is considered relevant to conduct a study with a group of college students to evaluate the level of math anxiety and its relationship with some variables.

To that end, an introductory mathematics course called MAT-001 General Mathematics delivered at the National University of Costa Rica was chosen. It serves as a basis for courses called Differential and Integral Calculus and Calculus I, and it is the only math course studied by students in 13 degree programs for their professional education. It is worth mentioning that such course is characterized by having 35% of approval.

Therefore, the following research questions are made, which is the math anxiety level showed by the students taking MAT-001 General Mathematics from the National University of Costa Rica and its relationship with the following variables: (a) gender; (b) academic achievement; (c) type of school where students graduated from; (d) course schedule; and (e) number of times the student has taken the course.

Definitions of Math Anxiety.

When doing a research on the definition of math anxiety, it can be verified that there are several concepts. However, all of them are related and follow a same line.

Fennema and Sherman (1976) state that math anxiety “is a series of feelings of anxiety, terror, nervousness and physical symptoms arising from performing math operations.” (p.4)

Richardson and Suinn (1972) define math anxiety as “feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of math problems in a wide variety of ordinary life and academic situations.” (p.551)

Furthermore, Tobías and Weissbrod (1980) state that “math anxiety is described as the panic, defenselessness, mental paralysis and disorganization that arises when a subject is required to solve a math problem.” (p.65)

Specifically, Perry (2004) defines different types of math anxiety in college students: (a) moderate and variable math anxiety; (b) math anxiety the student has suffered from for a long time as a result of teacher’s action; and (c) math anxiety caused by the mechanical learning method and the lack of understanding when learning mathematics.

Pérez-Tyteca and Castro (2011) consider it to be an affective state characterized by the lack of comfort, and it manifest itself through a series of “symptoms”, such as tension, nerves, worry, concern, irritability, impatience, confusion, fear and mental block.

Taking into account the above-mentioned definitions, this work states that math anxiety comprises nerves, tension, stress, mental block, physical symptoms, such as sweaty palms, stomachache, headache, among others, that a student has when performing math tasks.

Math Anxiety Study.

According to *Pérez-Tyteca (2012)*, one of the lines of research about math anxiety is the one that studies its relationship with some factors such as gender, academic achievement or degree choice.

As for gender, some studies (Hyde, Fennema, Ryan, Frost & Hopp, 1990; Hembree, 1990; Pérez-Tyteca, 2012; Valero, 1999) state that women are more anxious than men. However, other research works (Reyes, 1984; Perina, 2002) differ from the foregoing and state that the differences may be due to the fact that women are more honest about expressing their feelings of anxiety, while men are more reserved.

The relationship between math anxiety and degree choice has been also studied. Tobias and Weissbrod (1980); Ashcraft (2002); and Furner and Berman (2003) state that this may condition students their choice of degree that does not include mathematics courses due to their feeling of rejection of this discipline.

On the other hand, Pérez-Tyteca, Castro, Segovia, Castro and Fernández (2007) state that a high level of math anxiety makes difficult learning more complex exercises. In this regard, the studies conducted by Bursal and Paznokas (2006) and Pérez-Tyteca (2012) compared math anxiety with self-confidence, and it founds that the more math anxiety the student suffer, the lower self-confidence the student experience when solving math exercises.

Solazzo (2007) conducted a study about some factors related to achievement such as math calculations and mathematical reasoning skills. According to the study, both are negatively and significantly correlated with math anxiety. Gliner (1987) also studied factors such as the number of math courses studied by the student, gender, age, orthography, communication skills and math anxiety, and their relationship with academic achievement. This researcher found that gender, communication skills, number of courses taken by the student in the semester and the orthography, but not the academic achievement cause math anxiety.

As for academic achievement, it has been found that math anxiety shows a negative and significant correlation with this variable, so that the higher the math anxiety is, the lower the academic achievement will be (Aiken, 1970; Hembree, 1990; Reyes, 1984; and *Pérez-Tyteca, 2012*).

Eisele (1999) conducted a multiple regression analysis in order to determine the relationship between math anxiety, learning styles and achievement in a sample of 150 college students. She found that seven learning styles account for 29.9% of the change in the anxiety level and 5 of them account for 29.6% of the achievement.

Rahim and Koeslag (2005) studied the relationship between age and math anxiety. They found that older students showed lower math anxiety compared to younger students (between 20 and 24 years old). Regarding this, Malinsky, Ross, Pannels and McJunkin (2006) did a research about the relationship of math anxiety with factors like gender and age. The author works with 481 students younger than 19 and older than 30. They found a relationship between math anxiety and age, but they could not state that the older the student is, the higher the math anxiety will be.

Finally, Pérez-Tyteca (2012) says that currently math anxiety and exam anxiety are being addressed as two concepts clearly distinguished, and this is the perception supported by the author. Besides, Perina (2002) states that math anxiety and exam anxiety are related, since if a student feels math anxiety, it is expected that they suffer from exam anxiety.

Studies conducted in Costa Rica.

As it can be verified, math anxiety is a field of interest in Math Education. However, it has been rarely addressed in Costa Rica. Studies conducted by Meza, Agüero, Suárez and Schmidt (2014); Mena (2014); Castillo and Picado (2014) and Corrales (2014) and their results are briefly explained below.

Meza et al., (2014) analyzed the level of math anxiety of high school students from Costa Rica by applying the instrument created by Fennema

and Sherman (1976) to a non-probabilistic sample of 3725 students from 35 public schools of the country.

The study concluded that around 60% of the students showed low levels of math anxiety and only 3.4% of them showed high levels of math anxiety. In addition, women showed, although moderate, higher math anxiety than men, and Diversified Education students showed a higher level of math anxiety than third-term students.

Mena (2014) studied the math anxiety of students enrolled in courses of General Mathematics, Differential and Integral Calculus and Differential Equations at the Instituto Tecnológico de Costa Rica during the first semester 2013, and the instrument created by Fennema and Sherman (1976) was applied. Mena concluded that 85% of students showed a low or very low level of math anxiety and women were more anxious than men. Besides, Mena determined that there are significant differences between the levels of math anxiety of students of the General Mathematics course and the students of the Differential and Integral Calculus and Differential Equations courses.

Corrales (2014) also studies the level of math anxiety in high school students. For that reason, he applied the instrument created by Fennema and Sherman (1976) to students of three academic night schools from Costa Rica. The research concluded that 1.2% of students showed a very high level of math anxiety, that women are more anxious than men and that students in the second year of high school (14 years old) showed a higher level of math anxiety than students in the first, third and fifth year of high school.

Finally, Castillo and Picado (2014) studied math anxiety in high school students from technical schools from Costa Rica. The results exhibited that most students showed a very low math anxiety (59%) and that women had higher level of math anxiety than men. Besides, they found that there are statistically significant differences between the level of math anxiety and the school of origin.

Emotional Component in Math Learning.

Some authors (McLeod, 1992; Guerrero, Blanco and Castro, 2001) confirm the increase of publications, in the last years, about the affective aspect of the human being and their relationship with the math teaching-learning process, referring to the affective part, attitudes, emotions and beliefs of the individual. In relation thereto, Silver (1985) in his research works about problem solving defines the students' beliefs on math as a discipline.

Guerrero, Blanco and Castro (2001) show that beliefs, attitudes and thoughts influence directly the emotions and feelings. Besides, they say that according to our own perception and evaluation of events, our emotions and behavior change.

Moreover, the affective component plays a very important role in the successful learning of students in the math field, and in some occasions, these affective aspects are related to the student and are difficult to exclude (Gil, Blanco and Guerrero, 2005).

Like beliefs and attitudes, math anxiety is an important affective issue in math education. So to talk about math anxiety, it is necessary to first address the concept of anxiety in general. Some definitions of it are shown below.

Math Anxiety Level.

According to *Pérez-Tyteca (2012)*, math anxiety (MA) levels can be classified as follows:

- Very low MA: Mean score lower than 1.5
- Low MA: Mean score between 1.5 and 2.49
- Medium MA: Mean score between 2.5 and 3.49
- High MA: Mean score between 3.5 and 4.49
- Very high MA: Mean score higher than or equal to 4.5

To obtain the score of each student, questions of the instrument measuring the MA are taken into account. These questions use Likert scale with answer

options from 1 to 5; values selected by students are added and the result is divided by the total number of questions. These were the categories used in this research.

The objective of this research was to determine the relationship between math anxiety and variables like gender, academic achievement and type of school in students taking the course MAT-001 General Mathematics of the National University of Costa Rica.

Method

Type of Research.

According to Hernández, Fernández and Baptista (2010), this study is descriptive and correlational since it is aimed at showing and describing the relationships between the scores obtained from the variables: math anxiety and gender, academic achievement, number of times the student has taken the course and the type of school in students studying the course MAT-001 General Mathematics from the National University of Costa Rica. In addition, the design was descriptive and correlational and bivariate since it tried to determine the relationships between the above-mentioned variables (Sánchez & Reyes, 2002).

Participants.

Participants of the study are students enrolled in the course MAT-001 General Mathematics, during Term I 2015 at the National University of Costa Rica. The total sample was composed of 472 students, 203 were men and 269 were women; 129 students retook the course and 343 took it for the first time. Students were studying the following degrees: Biology, Economy, Theology, Mathematics Teaching, Philosophy, Religion Teaching, Sociology, Planning and Social Promotion, Business Administration, Science Teaching, Forestry Science Engineering, Topography and Cadastre Engineering, Environmental

Management Engineering, Trade and International Business, Cartography and Digital Design and Geographical Sciences.

Although the instrument was applied to all the groups, the sampling was purposive since only students inside the classroom were considered upon applying the instrument.

Instruments.

The questionnaire used corresponds to an adjustment of the scale prepared by Hopko, Mahadevan, Bare and Hunt in 2003, which was modified according to the context of Costa Rica and then it was validated by experts in Education, Statistics, Psychopedagogy and Educational Mathematics. In addition, a pilot test was applied and this allowed making some modification to it.

The instrument originally contained 9 questions that determine the level of math anxiety of students. However, taking into account the recommendations, two more questions were included, making a total of 11 questions. Each one of the items of the questionnaire contained 5 possible options of answers enumerated as follows: 1, 2, 3, 4 and 5. The score obtained for each student in the questionnaire corresponded to the sum of values marked in each question, divided by the total number of questions. For instrument reliability, Cronbach's alpha was used showing a value of 0.88, which allows ensuring the scale reliability.

Procedure.

The instrument was applied to all groups taking course MAT-001 General Mathematics, Term I 2015, in the 14th week of classes, in order to determine the level of math anxiety in students at that moment. It is important to mention that when the questionnaire was applied, two mid-term exams had already been taken and only the third and the last mid-term exams were not taken.

To apply the instrument, each one of the groups were asked to complete such questionnaire. Instructions were previously given in order to avoid mistakes

when completing it. Finally, they were told to answer the questions as honestly as possible and that the instrument was anonymous and confidential.

There was no a specific time to finish the instrument application. However, the approximate time to complete the questionnaire was 6 minutes. Since the course lasted 16 weeks, in week 14 they were working on the last content to be evaluated in the third mid-term exam.

Results

This work was aimed at determining the level of math anxiety of students enrolled in the course General Mathematics of the National University of Costa Rica and at establishing if there are significant relationship between (a) gender; (b) academic achievement; (c) type of school the student graduated from; (d) course schedule; and (e) the number of times the student has taken the course.

To determine if the differences found were statistically significant, the Univariate General Linear Model was applied. The level of significance chosen for hypothesis tests was .05. To verify the compliance with the supposed parameters, graphs were drawn to evidence that data showed a great trend towards a normal distribution, and the Levene test was used to verify that the data showed homoscedasticity or homogeneity of variances. $p = 0.424$.

Math Anxiety Study.

The average score of math anxiety of students polled was 2.89, value obtained from adding the data corresponding to the average score of each student and dividing this amount by the total number of students polled. This value (2.89) corresponded to a medium level of math anxiety according to Pérez-Tyteca (2012).

To obtain an average score of math anxiety from each student, questions 11 to 21 of the instrument were taken into account. Values selected by students were added and the result was divided by 11 (total number of questions of the

instrument). Table 1 shows the frequencies and percentages of the number of students distributed according to each level of math anxiety.

Table 1.

Frequency and Percentage of Students in each Level of Math Anxiety.

Level of math anxiety	Frequency	Percentage
Very low math anxiety	21	21
Low math anxiety	131	131
Medium math anxiety	206	206
High math anxiety	107	107
Very high math anxiety	7	7

Study of Math Anxiety according to Gender.

An analysis of levels of math anxiety was performed in men and women in order to observe if one of them showed higher levels of anxiety when dealing with math tasks. A statistical hypothesis testing was performed and it showed that the differences were statistically significant $p=.001$ with an effect size (partial eta squared) equal to .03. Table 2 shows the descriptive statistics of the math anxiety variable according to gender.

Table 2.

Descriptive Statistics of Math Anxiety according to Gender

Gender	Mean	N	Typical Deviation	Minimum	Maximum
Man	2.74	203	0.84	1.00	5.00
Woman	3.00	269	0.78	1.36	4.82
Total	2.89	472	0.82	1.00	5.00

According to the previous table, it can be observed that men showed lower math anxiety than women, which is evidenced in the mean score of men that was lower than that obtained for the sample; while women showed higher math anxiety. Figure 1 shows clearly this behavior.

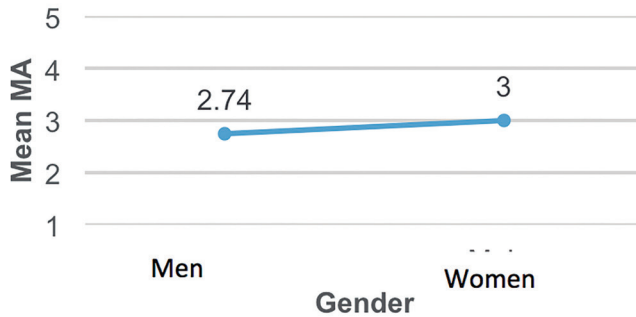


Figure 1. Math Anxiety according to Gender.

Study of Math Anxiety according to Academic Achievement.

To analyze the academic achievement variable, a statistical hypothesis testing was performed. Results show that there was enough statistical evidence to infer that the differences between academic achievement and math anxiety were significant $p < .001$, with effect size (partial eta squared) equal to .09.

Table 3 shows the descriptive statistics of this variable, which reflect that the lower the academic achievement of the student is, the higher the math anxiety will be.

Table 3.

Descriptive Statistics of Math Anxiety according to the Academic Achievement

Score obtained in the last test conducted in the course	Mean	N	Typical Deviation	Minimum	Maximum
Higher than 0 but lower or equal to 25	3.56	22	0.67	1.91	4.73
Higher than 25 but lower or equal to 50	3.06	91	0.86	1.18	5.00
Higher than 50 but lower or equal to 70	3.00	164	0.69	1.45	4.64
Higher than 70 but lower or equal to 85	2.68	124	0.79	1.00	4.82
Higher than 85 but lower or equal to 100	2.54	71	0.92	1.00	4.73
Total	2.89	472	0.82	1.00	5.00

Since the academic achievement is composed of 5 values and the differences are statistically significant, then multiple comparisons were conducted through the Scheffe method to determine between which levels there were differences.

The differences found between the value higher than 0 but lower or equal to 25 and the value higher than 70 but lower or equal to 85 $p < .001$, between the value higher than 0 but lower or equal to 25 and the value higher than 85 but lower or equal to 100 $p < .001$, between the value higher than 25 but lower or equal to 50 and the value higher than 70 but lower or equal to 85 $p = .008$, between the value higher than 25 but lower or equal to 50 and the value higher than 85 but lower or equal to 100 $p = .001$, between the value higher than 50 but lower or equal to 70 and the value higher than 70 but lower or equal to 85 $p = .034$, between the value higher than 50 but lower or equal to 70 and the value higher than 85 but lower or equal to 100 $p = .004$, were statistically significant; the other differences were not significant.

This indicates that there are two significantly homogeneous groups. The first group is composed of scores higher or equal to 0 and lower than 70; the second group is composed of scores higher or equal to 70 and lower or equal to 100. Figure 2 shows more clearly this behavior.

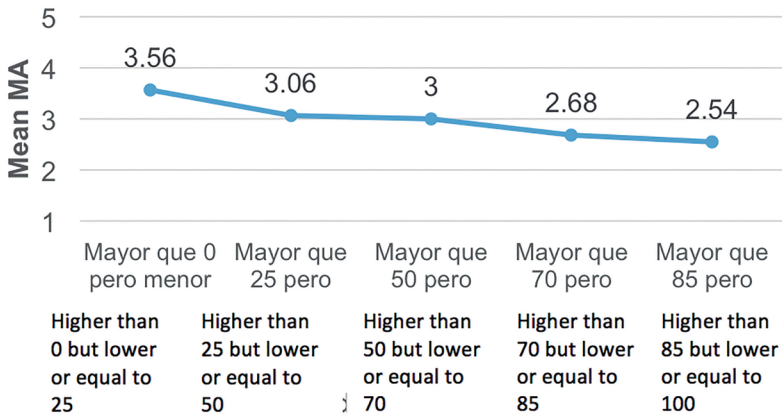


Figure 2. Math Anxiety according to Academic Achievement.

Study of Math Anxiety according to Type of School of Origin.

As for the study of type of school of origin, a statistical hypothesis testing was performed. Based on such test, there is enough statistical evidence to infer that the differences found between the type of school and math anxiety are significant $p < .001$, with an effect size (partial eta squared) equal to .04.

The following table exhibits the descriptive statistics showing the differences found.

Table 4.

Descriptive Statistics of Math Anxiety according to Type of School.

Type of School	Mean	N	Typical Deviation	Minimum	Maximum
Public	2.97	358	0.80	1.00	5.00
Private	2.60	106	0.80	1.09	4.45
Other (GED)	3.05	8	1.03	1.45	4.27
Total	2.89	472	0.82	1.00	5.00

Table 4 shows that the students graduated from private schools had lower math anxiety than their classmates. Besides, these students obtained a lower

score than the mean of the whole sample; while the other two types (public and General Equivalency Diploma) showed a higher score than the mean of the sample. This variable was found in the literature researched. Figure 3 specifies the behavior found.

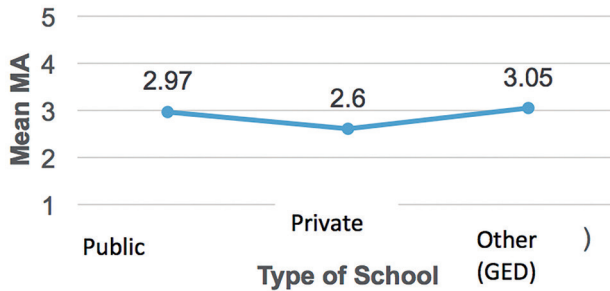


Figure 3. *Math Anxiety according to Type of School*

Discussion

Based on the results of the statistical analysis of data, it can be concluded that the students sampled showed a medium level of math anxiety. According to Pérez-Tyteca (2012), it would be ideal that the students who chose a degree program with at least one math content course do not show anxiety to this course. This result evidences that there is a problem, which is the first step to work later in intervention strategies that allow an adequate management of math anxiety in classroom, by the professor and the students.

Hypothesis testing allowed establishing the statistically significant differences between math anxiety and the variables of gender, academic achievement and type of school the student graduated from.

As for gender, there are statistically significant differences between men and women. Women show higher math anxiety. However, Perina (2002) and Reyes (1984) say that these differences can be due to the fact that women tend to admit more that they suffer from anxiety, while men are more reserved.

The results coincide with the research works conducted by Eshaq (2006), Hembree (1990); Hyde, Fennema, Ryan, Frost and Hopp (1990); Pérez-Tyteca (2012) and Valero (1999). This has been an introduction to math anxiety in men and women taking the course MAT-001 General Mathematics of the National University of Costa Rica. For that reason, it is important to deeply study this fact in order to determine its causes and the way to reduce it.

As for academic achievement, this research is in line with the results of Aiken (1970); Karasel, Ayda and Tezer (2010); Hembree (1990), Reyes (1984) and Pérez-Tyteca (2012) since it states that there is a negative relationship between these variables, as the lower the academic achievement is, the higher the anxiety will be when dealing with math tasks. It also found two significantly homogeneous groups, the first one had scores higher or equal to 0 and lower than 70 and the second group had scores higher or equal to 70 and lower than 100. This fact indicates that means of math anxiety of students with scores higher or equal to 70, are very similar. This situation is also evidenced in students with scores lower than 70, since this group indicates that means of math anxiety of these students are also very similar. It is considered appropriate to delve deeper into this behavior. Curiously, it is divided between passing students and the failure students. It would be helpful to research more about those similar characteristics of the students in each one of the groups.

As for the type of school of origin, students graduated from private schools obtained a significantly lower math anxiety than those from public school or from the General Equivalency Diploma program. A review of literature related to this variable was conducted and there were no studies that include it. So the research contributes with a new result in research works on math anxiety. This result is valuable since new studies addressing the causes for which students from public schools show higher math anxiety must be conducted. The Ministry of Public Education of Costa Rica is also recommended to inquire into the work conducted in the math area, since its

students are those who suffer more from anxiety when dealing with math tasks.

Finally, it is necessary to conduct other studies addressing math anxiety and other variables in order to go deeply into this topic and verify the results obtained in this research. It is also recommended to take into account other constructs of affective domain such as students' self-confidence or how they make mathematics useful. It is important to study thoroughly the comparisons between math anxiety and these constructs taking into account the above-mentioned variables and even some others.

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