Attitude toward usefulness of mathematics of Costa Rican high school students

Evelyn Agüero-Calvo[a] *, Luis Gerardo Meza-Cascante[a], Zuleyka Suárez-Valdés-Ayala[a]

[a]Technological Institute of Costa Rica, Cartago, Costa Rica

Abstract

This paper presents the results of a study of the attitude toward usefulness of mathematics demonstrated by the students of Costa Rican high schools enrolled in day schools. The attitude toward the usefulness of mathematics, according to Pérez-Tyteca (2012), connects to how helpful people believe that mathematics is for their personal life and their work and professional development.

The attitude toward the usefulness of mathematics of Costa Rican high school students was measured using the scale of Fennema-Sherman, which is widely used in educational research. The existence of differences in this variable by gender, by education level and by location of the school (urban or rural) were analyzed.

The research was based on a sample of 3703 students for the year 2016. The results show that approximately 65% of students have high or very high attitude toward usefulness of mathematics. Also, the results reveal significant statistical differences in the level of this variable based upon gender, showing that male students have the higher levels, and there is no statistical difference based on location of the school.

The findings also suggest that the lower levels of attitude are shown by the tenth graders and eleventh graders, which is worrisome because those students will soon face the choice of a university career, and the mathematical component is important for technology and science careers.

This study is another effort of the Mathematics Department of the Technological Institute of Costa Rica to advance studies on the so-called "emotional responses", given the growing recognition that these responses play an essential role in the process of teaching and learning mathematics.

Keywords: mathematics; attitude; secondary education.

* Corresponding author. Tel: +0-506-25502225
 E-mail address: evaguero@itcr.ac.cr

1. Introduction

In this article we report the results of an investigation about the attitude toward the usefulness of the mathematics of the students of Costa Rican secondary education, which is an advance in the studies on the so-called affective responses, given the growing recognition that these responses play an essential role in the process of teaching and learning mathematics.

The attitude toward the utility of mathematics refers to how useful people believe in mathematics for their personal life and for their professional development (Pérez-Tyteca, 2012). The importance of studying this construct is that "the usefulness that a student gives to mathematics is fundamental to determine his interest, motivation and persistence in the subject" (Pérez-Tyteca, 2012, p.59). Students have to constantly deal with the pressure exerted on their academic achievement in mathematics, so it is important to identify those aspects that have both positive and negative influence on mathematics.

According to Gómez-Chacón (2000, p.24),"attitudes toward mathematics refer to the appreciation of this discipline and interest in this subject and its learning, and emphasize more the affective component than cognitive; it manifests itself in terms of interest, satisfaction, curiosity, valuation, etc".

The affective dimension in the learning of mathematics reveals that affective questions play an essential role in the teaching-learning process of mathematics, and that some of them appear strongly rooted in people and are not easily displaced by the process of teaching (Gil, Blanco, and Guerrero 2006).

The study of these variables in secondary education is especially important because, according to Aschcraft (2005, cited by Primi, Busdragui, Tomasetto, Morsanyi and Chiesi, 2014, p.51), "interest and motivation decline as the student is growing, and mathematical anxiety is thought to develop in secondary education, coinciding with the growing difficulty of the mathematics curriculum". The importance of attitudes toward mathematics in the teaching-learning process and on the academic performance of the students is recognized (Miñano and Castejón, 2011, Miranda, 2012, Sakiz, Pape, and Hoy, 2012, cited by Palacios, Arias and Arias, 2014).

According to the results obtained by Mato, Espiñeira and Chao (2014), the attitude towards the usefulness of mathematics decreases as the students progress in their courses. These authors propose that such behavior can be explained by "how maths are presented, in many cases, away from real life, decontextualized so that students do not perceive what is the relationship of content given in school and mathematics of everyday life" (p. 70). Attitudes towards mathematics arise from very early ages, and although they tend to be favorable at first, they decline as students advance (Aliaga and Pecho, 2000, cited by Mato, Espiñeira and Chao, 2014) and a significant decrease occurs in opinions of its usefulness for the future (Watt, 2000 and Broc-Cavero, 2006, cited by Mato, Espiñeira and Chao, 2014).

The research community is aware of the influence of affective factors in the learning of mathematics, and for this reason, in the last years, the number of studies that have deepened in it has increased (Gómez-Chacón, 2010).

2. Method

The research is quantitative and descriptive.

2.1. Participants

The participants in the study were 3703 students from seventh to eleventh year of official public day schools of the Ministry of Public Education of Costa Rica, as shown in tables 1 and 2.

Table 1. Distribution by gender.

Gender	Frequency	Percent
Male	1729	46.7
Female	1974	53.3

Table 2. Distribution by education level.

Level	Frequency	Percent
7	767	20.7
8	782	21.1
9	726	19.6
10	759	20.5
11	669	18.1

The participating schools were selected by random simple stratified sampling according to the location area (table 3), and by population by province. The students selected for the study in each sampled school were those belonging to the second section of each level.

Table 3. Distribution by location of the school.

Location of the school	Frequency	Percent
Urban	2670	72.1
Rural	1033	27.9

2.2. Instrument

Attitude toward mathematics was measured using the Fennema-Sherman (1976) Attitude-to-Mathematics Scale test which contains 12 Likert-like items with five options from "totally agree" to "strongly disagree", which has been validated for more than 30 years in various investigations (Nortes and Nortes, 2014; Berenguel, Gil, Montoro and Moreno, 2015). This test is self-administered and each student responds anonymously and confidentially in accordance with his beliefs about himself in attitude toward the usefulness of mathematics, as stated in each item.

2.3. Procedure

The test described above was given to a group of each level in each selected school, with a previous introduction followed by the corresponding instructions. In each group, responses were collected in a pencil and paper format in approximately 15 minutes.

2.4. Statiscal analysis

With regard to the instrument of measurement, a study of its psychometric characteristics was carried out: index of discrimination, reliability and unidimensionality; in addition, the scores of the self-report of attitude toward the usefulness of mathematics were classified into five categories: very low, low, moderate, high and very high.

To prove the validity of the instrument, a study of the discrimination index of each item of the scale was carried out, calculating the correlation between the score contributed by the item and that obtained by the sum of the other eleven items (Lozano and De La Fuente, 2009). The interpretation of the value of discrimination rates was made based on the recommendations of Lozano and De La Fuente (2009).

We also studied the unidimensionality of the scale, that is, we showed that it essentially measures a single construct (attitude towards the usefulness of mathematics in this case), using factor analysis as the most used technique for these effects (Jiménez and Montero, 2013), after calculating the Kaiser-Meyer and Olkin (KMO) and Bartlett sphericity adequacy index. As a decision criterion, Carmines and Zeller (1979, cited in Burga, 2006), were used, which requires that the first factor explain at least 40% of the variance.

The reliability was studied based on the technique called Cronbach's Alpha, following Cea's (1999) approach that the minimum acceptable value is 0.80.

As part of the descriptive statistical analysis of the data, a scaling of the scores is performed following the interpretation proposed by Pérez-Tyteca (2012): to identify values close to 1 with a very low level of attitude toward the usefulness of mathematics, values around 2 with a low level, values around 3 as an average level, the next to 4 with a high level and values around 5 with a very high level of attitude toward the usefulness of mathematics.

Subsequently, the following three hypotheses were contrasted:
• Hypothesis 1: There are no differences in the attitude toward usefulness of mathematics by gender.
• Hypothesis 2: There are no differences in the attitude toward usefulness of mathematics by education level.
• Hypothesis 3: There are no differences in the attitude toward usefulness of mathematics by location of the school.

For the case of the hypotheses related to the differences of means involving two categories (gender and location of the school) we used the Student t parametric test, assuming the normal distribution of the data based on the central limit theorem. For the hypothesis related to the educational level the Welch test is used, complemented by the posteriori test of Dunnett.

Finally, the size of the effect is calculated for the cases in which the existence of statistically significant differences was detected using Cohen's *d* (Ripoll, 2011), which represents the number of typical deviations that separate two groups. The interpretation of the magnitude of the effect sizes measured by Cohen's d is based on the references given by Cohen (Morales, 2008 and Ripoll, 2011): around 0.20 there is a small difference, around 0.50 a moderate difference and 0.80 or more a large difference.

3. Results

3.1. Instrument

For the study of the psychometric characteristics of the instrument used in this study, it was determined that the discrimination index obtained for each item is adequate; but to ensure unidimensionality, item 11 was eliminated and, therefore, subsequent analyzes are carried out based on 11 items.

Then, the value obtained from the statistic called Cronbach's Alpha was $\alpha = 0.846$ which indicates that the instrument is highly reliable.

Subsequently, it was determined that the instrument is unidimensional according to the KMO index whose value was 0.904 with a p value <0.05, and a first factor that represents 40.65% of the total variance explained.

3.2. Classification of the attitude level toward the usefulness of mathematics

The mean attitude level toward the usefulness of mathematics ($M = 41.23$, $SD = 7.25$) was significantly higher than the average of the scale ($t(3702) = 69.038$, $p <0.05$), indicating that globally students of the sample present a level of attitude toward the usefulness of mathematics above average, that is, they manifest in general levels of attitude toward the usefulness of mathematics favorable.

With respect to the scores obtained for the attitude toward the usefulness of mathematics, table 4 shows the percentages by category.

Table 4. Categories of attitude toward the usefulness of mathematics

Categories	Frequency	Percent
Very low	12	0.3
Low	129	3.5
Moderate	1124	30.4
High	1970	53.2
Very high	468	12.6

These results indicate that approximately 83.6% of the students show an attitude toward the usefulness of mathematics between high and moderate.

3.3. Contrast of hypothesis 1

For the contrast of the first hypothesis, the mean of males ($M = 41.62$, $SD = 7.26$) was compared with the mean of females ($M = 40.88$, $SD = 7.23$), and a statistically significant difference was found with a small effect ($t(3701) = 3.064$, $p<0.05$, $d = 0.10$). That is, the null hypothesis is rejected and it is accepted that there are differences in the level of attitude toward the usefulness of mathematics between men and women, showing men a better level of attitude toward the usefulness of mathematics.

3.4. Contrast of hypothesis 2

For contrast of the second hypothesis, we compared the mean of the five educational levels using the Welch test, because the Levene test ($p<0.05$) indicates that there is no homogeneity of variances. It was determined that there are statistically significant differences between at least one pair of means of the five levels ($F(1828.37) = 13.784$, $p<0.05$). To detect at which levels these differences occur, Dunnett's post-hoc test was used, which indicates that the mean attitude toward the usefulness of mathematics is significantly higher at the seventh level ($M=42.34$, $SD=6.42$) than at the ninth ($M = 41.20$, $SD = 7.21$, $p<0.05$), tenth ($M=40.22$, $SD=7.49$, $p<0.05$) and eleventh ($M=40.23$, $SD=8.22$), $p<0.05$), also the mean attitude toward the usefulness of mathematics is significantly higher at the eighth level ($M = 41.98$, $SD = 6.69$, $p<0.05$) than at the tenth and eleventh levels. That is, the null hypothesis is rejected and it is accepted that there are statistically significant differences in the level of attitude toward the usefulness of mathematics between the seventh level compared to the ninth, tenth and eleventh levels and eighth compared to the tenth and eleventh levels, evidencing in this way lower levels of attitude towards the usefulness of mathematics in the levels of diversified education.

3.5. Contrast of hypothesis 3

For the contrast of the third hypothesis, the mean of the urban area ($M = 41.24$, $SD = 7.37$) was compared with the rural area mean ($M = 41.20$, $SD = 6.93$), and no statistically significant difference was found between them ($t(3701) = 0.155$, $p> 0.05$). That is, the null hypothesis is accepted that there are no differences in the level of attitude towards the usefulness of mathematics according to the location of the school.

4. Discussion

The research focused on the attitude toward the usefulness of mathematics of Costa Rican high school students enrolled in day schools, with the general aim of measuring the level of attitude toward the usefulness of mathematics and to establish if there are differences in this variable by gender, by educational level or by location of the school.

The results suggest that, together, 83.6% of the students show levels of attitude toward the usefulness of mathematics between high and moderate.

The research also reveals that women have lower levels of attitude toward usefulness of mathematics than men, a result that coincides with those obtained in other studies (Pérez-Tyteca, 2012), although as this author warns, not all studies coincide in these results and often show inconsistencies.

Although no causal relationships have been established to explain these differences, Fennema (1996, cited by Pérez-Tyteca, 2012), argues that discrepancies are due to factors such as economic status, ethnicity, school or teacher, i.e., such differences between men and women in the level of attitude toward the usefulness of mathematics could be explained by the socio-cultural and economic context in which they develop, opening an interesting research agenda in Costa Rica where no explanatory studies have been carried out for the differences found.

The research also showed differences in the level of attitude toward the usefulness of mathematics between the seventh level compared to the ninth, tenth and eleventh levels, and between the eighth level compared to the tenth and eleventh levels, evidencing lower levels of attitude toward the usefulness of mathematics in tenth and eleventh, which coincides with

the results of other researches that have shown that adolescents tend to show decreasing levels in socio-economic variables related to mathematics (Pérez-Tyteca, 2012).

This finding, which is consistent with those found in Agüero, Meza, Suárez and Schmidt (2017) that show that the last levels of secondary education show higher levels of mathematical anxiety, is worrisome from the perspective of career choice. The fact that the students show decreasing levels in their attitude toward the usefulness of mathematics as they advance in their passage through secondary education could affect the choice of university career.

Finally, the research found no difference in the level of attitude toward the usefulness of mathematics according to the area of the school's location. The finding is interesting because differences were expected against students in rural schools, as it is known that these institutions face unfavorable conditions for the teaching of mathematics compared to those in urban areas (Meza, Agüero and Calderón, 2013).

The results suggest, at least, the following lines of research: to deepen the causality of the differences detected in the level of attitude toward the usefulness of mathematics by gender and those that can explain why the level of attitude toward the usefulness of mathematics decreases in the students of the Diversified Education, incorporating explicitly, as Gómez-Chacón (2000) has suggested, the study of the social reality that produces these reactions and the sociocultural context of the students.

Acknowledgements

References

Agüero, E., Meza, L. G., Suárez, Z., & Schmidt, S. (2017). Estudio de la ansiedad matemática en la educación media costarricense. *Revista Electrónica de Investigación Educativa*, *19*(1), 35-45. Retrieved from http://redie.uabc.mx/redie/article/view/849

Berenguel, E., Gil, F., Montoro, A.B., & Moreno, M. (2015). Influencia de la autoconfianza y el perfil motivacional en el "flujo" en matemáticas. In C. Fernández, M. Molina & N. Planas (Eds.), *Investigación en Educación Matemática XIX* (pp. 173-181). Alicante: SEIEM.

Burga, A. (2005). *La unidimensionalidad de un instrumento de medición: perspectiva factorial.* Lima: Ministerio de Educación.

Cea, M.A. (1999). *Metodología cuantitativa: estrategias y técnicas de investigación social*. Madrid: Síntesis.

Fennema, E. y Sherman, J. A. (1976). Fennema-Sherman mathematics attitude scales. Instruments designed to measure attitudes toward the learning of mathematics by males and females. *Journal for Research in Mathematics Education*, 7(5), 324-326.

Gil, N., Blanco, L., & Guerrero, B. (2006). El papel de la afectividad en la resolución de problemas matemáticos. *Revista de educación*, (340), 551-569.

Gómez-Chacón, I.M. (2000). *Matemática emocional*. Madrid: Narcea.

Gómez-Chacón, I.M. (2010). Actitudes de los estudiantes en el aprendizaje de la matemática con tecnología. *Enseñanza de las ciencias*, *28*(2), 227–244. Retrieved from http://eprints.ucm.es/21500/1/IGomez1.pdf

Jiménez, K. & Montero, E. (2013). Aplicación del modelo de Rasch, en el análisis psicométrico de una prueba de diagnóstico en matemática. *Revista digital Matemática, Educación e Internet*, *13*(1), 1-24.

Lozano, L. & de la Fuente-Solana, E. (2013). Diseño y validación de cuestionarios. In Pantoja-Vallejo (Ed), *Manual básico para la realización de tesinas, tesis y trabajos de investigación* (pp. 251-274). Spain: Editorial EOS.

Mato, M. D., Espiñeira, E., & Chao, R. (2014). Dimensión afectiva hacia la matemática: resultados de un análisis en educación primaria. *Revista de Investigación Educativa, 32*(1), 57-72. doi.org/10.6018/rie.32.1.164921

Meza, L. G., Agüero, E. & Calderón, M. (2013). La teoría en la práctica educativa: una perspectiva desde la experiencia de docentes graduados/as de la carrera "Enseñanza de la matemática asistida por computadora". *Revista digital Matemática, Educación e Internet*, *13*(1), 1-24.

Morales, P. (2008). *Estadística aplicada a las Ciencias Sociales*. Madrid: Universidad Pontificia Comillas.

Nortes, R. & Nortes, A. (2014). ¿Tienen ansiedad hacia las matemáticas los futuros matemáticos? *Profesorado. Revista de currículo y formación del profesorado, 18*(2), 153-170. Retrieved from http://www.redalyc.org/articulo.oa?id=56732350009

Palacios, A., Arias, V., & Arias, B. (2014). Las actitudes hacia las matemáticas: construcción y validación de un instrumento para su medida. *Revista de Psicodidáctica*, *19*(1), 67-91.

Pérez-Tyteca, P. (2012). *La ansiedad matemática como centro de un modelo causal predictivo de la elección de carreras.* (Unpublished doctoral dissertation). University of Granada, Spain.

Primi, C., Busdraghi, C., Tomasetto, C., Morsanyi, K., & Chiesi, F. (2014). Measuring math anxiety in Italian college and high school students: validity, reliability and gender invariance of the Abbreviated Math Anxiety Scale (AMAS). *Learning and Individual Differences*, *34,* 51-56. doi:10.1016/j.lindif.2014.05.012

Ripoll, J. (2011). *La d de Cohen como tamaño del efecto*. Retrieved from: http://clbe.wordpress.com/2011/10/26/la-d-de-cohen-como-tamano-del-efecto.