

Student Perception toward Computer in Teaching-Learning Math in Tertiary Education. A Theoretical Construct Validation

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ABSTRACT

Nowadays the process for teaching mathematics has developed principally through information and communications technologies (ICT), especially through the use of computers. The purpose of this study is to show if the theoretical model proposed by Galbraith and Hines adjusts to data provided by students at Universidad Cristóbal Colón. The sample is composed by students in the fields of economics and administration, and used the scale designed by Galbraith and Haines (1998). This scale consists of five sections: mathematics confidence, mathematics motivation, mathematics engagement, computer confidence, and computer and mathematics interaction. The statistical technique used to evaluate the data was Structural Equations. The goodness of fit indices CMIN/DF = 1.080, GFI = .993, AGFI = .979, CFI = .995, RMSEA = .016, indicate that the hypothetical model adjusts to the theoretical model proposed by the authors cited above.

Introduction

Students' performance in mathematics is a topic currently under discussion from the theoretical perspective of anxiety, confidence, and other variables associated to this phenomenon. It is also certain that the inclusion of information and communication technologies has had a meaningful impact on mathematics teaching, as shown by studies carried out by Galbraith and Hines, (1998).

In this same vein, in a recent exploratory study, García-Santillán, Escalera-Chávez, Córdova and López (2013) pointed out that students show a clear tendency toward an attitudinal deficiency, and this can be primarily understood as an intolerance toward mathematics. This topic has been discussed in numerous studies. At the same time, these authors highlight the existence of creative students, who see in mathematics a means to solve real-problems. Mathematics provides them with the capacity to seek, ask, inquire, and research problems they want to solve.

Children begin by exploring their world, associating objects and person in an imaginary which only psychology can explain as an instinctive act. Curiosity come to be a determining variable in teaching processes in any discipline, including mathematics, the object of this study. Students are creative in the same measure they are curious; this becomes an essential element in the search for solutions to mathematical problems, as shown in their study by García-Santillán *et al* (2013)

In the same study, García *et al* (2013) make reference to Fey's postulate (1989) about the use of technology in the teaching-learning process of mathematics. In his word's Fey's say:

"...it is very difficult to determine the real impact of those ideas and development projects in the daily life of mathematics classrooms, and there is very little solid research evidence validating the nearly boundless optimism of technophiles in our field." (Op cit, 1989)

What has motivated different studies in regards to the golden trilogy: learner, mathematics, and computer are precisely the question what is the nexus between mathematics and technology. A seminal referent in trying to explain this phenomenon is the study by Galbraith and Haines (1998), *"Disentangling the nexus: Attitudes to mathematics and technology in a computer learning environment"*. Here they refer that a distinction must be made between the relationship between mathematics and ICTs, and technology applied to the mathematics teaching-learning process. This relationship is envisioned as two constructs which must be dealt with individually, given that including technology modifies the educational process.

Other arguments, such as those of Kaput and Thompson (1994) have added to this theoretical discussion. In this regard they point out that technological innovations have been developed to solve other types of problems, not necessarily the process of mathematics teaching. What they propose is in contrast to other studies, such as those by Auzmendi (1992), García, Edel and Escalera (2012). It must be considered however, that, though it is true that technology *per se* was not created for the educational process, it has been of great use in the teaching-learning process, and attempts have been made to adapt the mathematics syllabus, as stated by Galbraith and Hines, (1998).

Justification

Knowledge of mathematics is very important in people's lives. Thus, it is necessary to understand and use mathematics correctly in daily life. In the United States, the National Council of Teachers of Mathematics (2004) has indicated that using mathematics had never been as important as it currently is, and that day by day this need is increasing, since mathematics is essential for life, is part of our cultural heritage and is necessary for work.

In the process of teaching and learning mathematics, ICTs have taken on a relevant role. Thus, it becomes indispensable to study them as tools to overcome attitudinal deficiencies and to provide feedback to the principal actors in student learning.

This study, carried out among students at a private university in the Mexican state of Veracruz, offers evidence which allows us to identify if the attitude toward mathematics is influenced by the use of information technologies-specifically, computers- in the teaching and learning process. Thus, the finding of this study will contribute to existing knowledge on the topic, in regards to constraints and scope. The study intends to obtain information and data which will allow us, as much as possible, have sustainable arguments to guide both teachers and students in the better development of the process of teaching and learning mathematics.

Empirical Studies

Attitude represents an emotional reaction toward an object. It is the belief one has in regards to an object, or one's behavior toward this object. Meanwhile, emotion means enthusiasm produced by a stimulus (McLeod, 1989a). These dimensions represent the affective part of the human being, and they can be present in greater degree in an individual, decreasing the cognitive aspect. In other words, passion increases, and knowledge decreases.

Attitude can be seen as the result of emotional reactions which have been interiorized and transformed (McLeod, 1989) to generate feelings of moderate intensity and reasonable

stability. Marshall (1989) has proposed the hypothesis of a mechanism for cognitive development, attitude situated in the concept of network of human memory (Anderson, 1983, 1995). Here, attitude represents the evocation of stored affective memories, which implies a dispassionate response. Attitudes are expressed along a positive-negative continuum (pleasant-unpleasant).

Attitude in mathematics, in the words of Gal and Garfield (1997), is the sum of emotions and feeling experienced throughout time in regards to the learning of mathematics. In this context, it has a more stable understanding over beliefs than over cognition.

Other studies have added to the argument about the growth of technologies and their influence on the educational process of mathematics teaching. The impact has been defined as favorable in the field of mathematics teaching at all levels (Goldenberg, 2003), Moursund (2003), García and Edel (2008), García-Santillán, Escalera and Edel (2011), García-Santillán and Escalera (2011). In this same regard, Gómez-Chacón and Hines (2008), Noss (2002) and Artigue (2002) have demonstrated that technology use in mathematics teaching favors student performance. In fact, some studies highlight the existence of cognitive and affective demands present among the student population in specific programs which include technology (Pierce and Stacey, 2004; Galbraith, 2006; Tofaridou, 2007).

Derived from the above arguments, García-Santillán et al (2013) highlight an important element for scholarly discussion; that is, precisely, the extreme care which should be given to the dialectic aspect, both technical and conceptual, within the process of mathematics teaching. This specifically in the fields where technology must be included, through graphing, calculators or any computer-based resources.

Other research into the topic of attitude toward mathematics and computers, such as Cretchley and Galbraith, (2002) has found evidence on the dimension which integrate this variable: commitment, motivation, confidence, and interaction between mathematic and computers. Other studies suggest there is a weak relationship between mathematics and attitude toward computers, in regards to confidence and motivation, versus the use of technology in the mathematics teaching-learning process (García-Santillán et al, 2013).

On the other hand, other authors, such as Crespo (1997) cited in Poveda and Gamboa (2007) question whether technology is the "magic formula", though it has been propounded as such. Of course, technology per se is not the solution to the problem of an apparent attitude of rejection toward mathematics on the part of the student. It can be, however, an important means for transforming traditional classroom with blackboards, erasers, desks, and other instruments of the old school into interactive classrooms which generate learning spaces mediated by ICTs, as has been referred by Gómez-Meza (2007), cited in Poveda and Gamboa, (2007). This same author mentions that, though technology is not the magic formula, nor the solution to all educational ills, what is true is that technology can by a change agent who promotes mathematics teaching and learning.

Theoretical Foundations

This confirmatory study on the validation of a theoretical model explaining the construct of attitude toward mathematics, is an extension of an exploratory study by García-Santillán et al (2013) carried out among students at the Universidad Politécnica de Aguascalientes, where surveys were applied to 164 students of different fields of study, such as: administration and business, mechatronics engineering, industrial engineering, strategic systems engineering, and mechanical engineering.

Both works are based on the theoretical proposal of Galbraith and Haines (1998) on the component elements of attitude toward mathematics, that is: motivation, confidence, commitment, computer confidence, and mathematics-computer interaction. In addition to this seminal referent, they include the contribution of Cretchley, Harman, Ellerton and Fogarty (2000) on the use of technology in mathematics teaching, and its theoretical reality.

From this theoretical construction stems the aim of the present study, which seeks to demonstrate if the model proposed by Galbraith and Hines fits the data collected during the field work with students at Universidad Cristóbal Colón.

From the above, we derive a preliminary question: Does technology really generate a change in mathematics teaching? In this regard, there have been pronouncements such as those of Karadag and McDougall (2008) who postulate that, regardless of the theoretical and practical implications of all that has proposed about teaching mathematics and the inclusion of technologies in the curriculum, it is clear that a large part of the population uses technology on a daily basis. This is especially true in the case of students, who cannot conceive of life without these indispensable tools- the computer and the internet. It is important to remember that these generations have been born in the information age (the Net generation), and thus they are confident in their use of technology.

Regarding this rationale from Karadag and McDougall (2008), it is interesting to revisit what Galbraith (2006) said about the use of technology. He referred to it as "an extension of one's self". The relationship between student and technology is direct; it becomes part of the identity, and, certainly, it affects the process of teaching and learning mathematics.

Other theoretical arguments have added to this debate. Its postulates refer that students as well as the academic institutions where they are formed professionally, have been capable of using technology in an effective way, as had been foreseen (Lagrange, 1999; Artigue, 2002; Izydorczak, 2003; Moreno-Armella and Santos-Trigo, 2004; Moyer, Niexgoda and Stanley, 2005; Kieran and Drijvers, 2006; Kieran, 2007 and Karadag and McDougall, 2008).

In the same vein of ideas, García-Santillán et al (2013) make reference to Suurtamm and Graves (2007), who mention that the Ontario Ministry of Education has proposed that, in order for students to improve their capacity for research and analysis of mathematics concepts, they should use technological tools such as calculators or computers which allow them to solve problems more rapidly, even those problems which may be impossible to solve with a paper and pencil. With the use of such tools, it becomes possible for students to solve mathematical problems quickly, in the context in which they develop.

These tasks can include doing complex arithmetic operations. In this sense, and continuing with the objective of the study, it is important to explain the particular view of computational mathematics attitudes. Thus, we include an operational definition for each of the five dimensions of attitude toward mathematics described by Galbraith and Hines: mathematics attitude, computer attitude, computer-mathematics interaction, and mathematics commitment.

To better understand the above-mentioned dimensions, and considering that the field of academic motivation could question the conceptual distinction between mathematics "confidence" and mathematics "motivation", it is important to highlight the explicit operational definition for each of these dimensions. Scholarly tradition has given rise to different theories of motivation; as a consequence, a conceptually different series of constructions of motivation has been identified.

Theories of motivation arise from different perspectives, and thus can focus on beliefs, values, or objectives. This field, in general, agrees that to examine a broad concept of "motivation" is not productive, and that research should concentrate on specific construction within motivation.

The scales designed by Galbraith and Haines (1998) were built upon parallel components on the attitude scale of Fennema and Sherman (1976), but designed to make them appropriate for use among undergraduate students. Five constructs make up the scale; in which each section is comprised of eight indicators (see Figure 1). Regarding mathematics confidence and mathematics motivation, Galbraith and Hines, state:

Mathematics confidence: Students with high confidence toward mathematics believe they get value for their effort, do not worry about learning difficult topics, expect to get good results, and feel good about mathematics as a subject. Students with low confidence are nervous about learning new material, expect all mathematics will be difficult, are naturally weak in mathematics, and care more about mathematics than any other subject.

Mathematics motivation: Students with high motivation toward mathematics enjoy doing mathematics problems, persevere until a problem is solved, think about mathematics outside of class, and become absorbed in their mathematical activities. People with low motivation do not enjoy mathematics challenges, are frustrated by having to spend time on problems, prefer to have the answers instead of being left with a problem and cannot understand people who are excited about mathematics "(op. cit, 1998.) Attitudes toward computer use scales were designed to parallel the corresponding mathematics scales.

Confidence toward computers: Students who demonstrate a high degree of confidence in computers believe they can master the necessary software procedures; they also feel more confident in their answers when they do calculations on computer equipment, therefore, they are more confident about solving problems by themselves. On the other hand, students with low computer confidence feel disadvantaged by having to use computers; they feel anxious about using the computer to perform calculations within their learning process. In short, they do not trust computers to produce correct answers, and panic leads them to commit errors when a computer program is used.

Computer Motivation: Students who demonstrate high computer motivation create their own learning activities, as they find it more enjoyable. They have the freedom to experiment and are more likely to spend long hours at a computer to perform a task and enjoy trying new ideas on a computer. Students with low computer motivation avoid using computers; they feel that their freedom is being eroded by the limitations of the program because they think that computers make students mentally lazy.

As to computer-mathematics interaction, the importance of this partnership has been studied by different authors, including the following: Lester, Garofalo and Kroll (1989), McLeod (1985) and McLeod (1989b). These authors have come to the conclusion that when the student is not familiar with the technology, this can cause special difficulties. Given the importance of this interaction, authors such as Reif (1987), Chi, et al (1989) and Anderson (1995) have mentioned that, by interacting with learning materials, such as pencil and paper, or a computer screen, the brain adds a dimension to the cognitive processes in student learning.

In regards to "participation in mathematics learning", we can point out that some studies have contributing to the understanding of this phenomenon. These reveal that student commitment toward learning mathematics yields efficient and valuable results. It has been demonstrated that some experts have effectively used some mechanical concepts in mathematics teaching (Reif, 1987). Likewise, other studies have shown how examples can construct a powerful framework for learning (Reder et al, 1986; LeFavre y Dixon, 1986). Students who learned committed to generating more ideas than students who did not (Chi et al., 1989).

Meanwhile, Swing and Peterson (1988) demonstrated that integration and development processes, such as analysis, definition, and comparison, are related to greater learning. Another study, this one carried out by Reder and Anderson (1980) showed that summaries support effective learning. Anderson (1995) has demonstrated that when these factors are frequently associated to concepts in the learning process, the information received by the student can be more easily recalled. Likewise, if the information is interconnected in a knowledge network, it can lead to better results for the learner.

In sum, it can be said about mathematics commitment: students who got higher scores on this scale prefer to work through examples, than with the given materials, and vice-versa; students with a lower score on the scale prefer to learn with materials than through examples.

The above discussion allows us to identify the variables in the object of study, as illustrated in the following construct, where are discussed the variables proposed by Galbraith and Haines (1998) about: mathematics confidence, mathematics motivation, mathematics commitment, computer confidence, and mathematics-computer interaction, all of this within a trilogy: student, computer, and mathematics.

Methods

For the purposes of this study, the sample is non-probabilistic. The selection of the elements does not depend on probability, but on the causes related to the characteristics of the investigation, and, of course, the selected samples obey other research criteria (Hernández, Fernández, Baptista 2006). The study sample is made up of 303 students of Universidad Cristóbal Colón from various fields of study: Economics, Administration, Accounting, Marketing, and Tourism Business Management.

The criteria selection for including the surveyed students were: they had to have completed at least one course on mathematics within their undergraduate program, and, finally, that they were available on the day the survey was applied. The scale used was developed by Galbraith and Haines (1998), and consists of five sections: mathematics confidence (Items 1 to 8), mathematics motivation (Items 9 to 16), mathematics commitment (Items 17 to 24), computer confidence (items 25 to 32), and mathematics-computer interaction (Items 33 to 40). Each section consists of eight elements evaluated with a Likert scale. The scale ranges from 1 (low) to 5 (very high).

To process the data, the AMOS v 21 program was used. The statistical technique used to prove if the theoretical model proposed by Galbraith and Haines (1998), fits the data was Structural Equations, due to its great potential for broadening the development of a theory (Gefen, Straub and Boudreau (2000)). The hypothetical model was evaluated by various goodness of fit measures to assess in what measures the data support the theoretical model. These were the following: statistical likelihood ratio Chi-square (χ^2) and Mean Squared Residue (RMSEA), GFI (Goodness of Fit Index), AGFI (Adapted Goodness of Fit Index), CFI (Comparative Fit Index) (Hair, et al. 1998).

Hypothesis

If the anxiety toward mathematics model is a five-factor structure: mathematics confidence, mathematics motivation, mathematics commitment, computer confidence, mathematics-computer interaction. Therefore the hypothesis is:

H1: The anxiety toward mathematics could be explained by the structure of a model which integrate five-factor: mathematics confidence, mathematics motivation, mathematics commitment, computer confidence and mathematics-computer interaction.

The graphic representation model is presented in Figure 1:

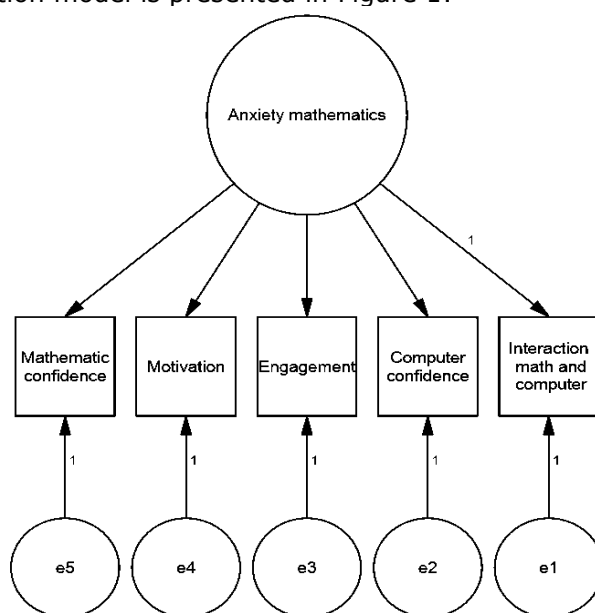


Figure 1: Theoretical model of Galbraith and Haines (1998)

Results

The results are presented in three sections: a) Summary of the Model, b) Variables of the model and parameter c) Evaluation of the model. With respect to the status summary of the model, fifteen elements are registered in the covariance matrix. Of these, ten are estimated parameters with positive degrees of freedom ($5 = 15 - 10$). This indicates that the model is over-identified and the Chi squared can be estimated (X^2) 5.399 with a level of probability of 0.369, which indicates that the model is significant.

Table 1: Weight, measurement error, reliability and covariance of variables

Variable		Weight		Significance	
Interaction		0.513			
Confidence		0.325		3.59	
Commitment		0.323		3.58	
Motivation		0.597		4.43	
Mathematics-Computer Confidence		0.397		4.07	
Indicator measurement error					
	Interaction	Confidence	Commitment	Motivation	Confidence Mathematics
Interaction	0.737				
Confidence	0.000	0.894			
Commitment	0.000	0.000	0.896		
Motivation	0.000	0.000	0.000	0.644	
Confidence Mathematics	0.000	0.000	0.000	0.000	0.842
Reliability = 0.5365					
Variance					
	Estimation	S.E.	C.R.	P	
F1	3.444	1.065	3.233	.001	
e1	9.616	1.109	8.671	***	
e2	18.547	1.660	11.175	***	
e3	24.193	2.163	11.183	***	
e4	7.253	1.055	6.875	***	
e5	12.941	1.234	10.486	***	

Source: own

The parameters to evaluate the model are ten, which correspond to the regression weights, six variances, which give a total of 16 parameters to estimate. With respect to the variables, it can be seen that there are 11 variables in the model, of which five correspond to the number of observed variables, and six to non-observed variables. In order to estimate if the hypothetical model is a good fit, we evaluated: 1) the estimated parameters, and 2) the complete model.

With respect to the first point, reliability of the parameter of Table 1 was estimated. It was observed that the parameters of the weights and variances are viable, and the value of reliability is 0.5365. There are no negative variances, and all are significant, (greater than 1.96). Furthermore, the table shows the values for measurement error for each indicator, and all are positive. This indicates that the variables are related to their constructs.

Global fit model: Table 2 provides the quality measurement for absolute fit.

Table 2: Measures Goodness of Fit: Revised model and null

Indices	CMIN	CMIN/DF	GFI	AGFI	CFI	RMSEA
Values	5.399	1.080	.993	.979	.995	0.016

Source: Own

The index sample chi square is a satisfactory fit ($\chi^2 = 5.399$, $df = 5$, $sig = .369$). The values of GFI (.993), AGFI (.979), CFI (.995) and RMSEA (0.016) are satisfactory because their values tend to one and are greater than 0.5 (Byrne, 2000).

Upon acceptance of the model (as a whole), the construct in order to check the internal consistency of all indicators to measure the concept was evaluated.

The results in Table 3 indicate the reliability value associated with the construct and this is 0.5365, less than recommended (0.70), indicating that the indicators are not sufficient to represent each of the dimensions.

Table 3: Reliability and Variance Extracted

Indicators	Reliability	Mean Variance Extracted
Ansiedad hacia la mathematics	0.5365	0.350

Source: Own

The table also shows the extracted variance, which must be greater than 0.50. In this case the value is less than 0.5. This means that more than half of the variance indicator is not taken into account for the construct.

Conclusions

The results give evidence that the structure specified in the hypothetical model is significant when applied to students of Universidad Cristóbal Colón. That is, the data fit the proposed model. The results are consistent with those of other authors (García-Santillán, Escalera and Edel 2011, García-Santillán and Escalera, 2011) who show that the presence of technology stimulates mathematics learning. It is also important to point out that the results of the study have a theoretical implication, because they support the theoretical foundation proposed by Galbraith and Haines (1998). The constructions considered by the authors are of statistical and practical significance in the students who were the object of this study.

Furthermore, the evidence obtained in this study contributes to predict the reality described by the authors in regards to attitude toward mathematics. At the same time, they give light to establish new question in the search for more knowledge. However, it is important to mention that it is necessary to explore additional weightings for the indicators, since the values of variance are low.

At the same time, the practical implications come about because the results are useful for higher education institutions to carry out teaching strategies focused on the use of information technology. It is important to conduct a larger effort by the teachers of the subject, encourage them to use these technological tools in such a way that they increasingly strengthen students' attitude toward mathematics.

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