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ATTITUDE AND BEHAVIORAL AMONG STUDENTS, COMPUTERS AND MATHEMATICS: (A CASE STUDY IN PUBLIC UNIVERSITY)

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ABSTRACT: *In this paper we examine the relationships between students' attitudes towards mathematics and technology; therefore, we take a Galbraith and Haines' scale (1998) about mathematics confidence, computer confidence, computer and mathematics interaction, mathematics motivation, computer motivation, and mathematics engagement. This is a study carried out at the Universidad Politécnica de Aguascalientes. 164 questionnaires were applied face to face to undergraduate students of several profiles: business and management, mechatronic engineering, industrial engineering, strategic system engineering and mechanic engineering. Statistical procedure was used the factorial analysis with an extracted principal component in order to measure data. Statistics test to prove:* X^2*, Bartlett test of sphericity, KMO (Kaiser-Meyer_Olkin), MSA (Measure sampling adequacy), Significance level:* $\alpha=0.05$*;* $p<0.05$ *therefore reject Ho if* $X^2_{calculated} > X^2_{tabulated.}$ *. The results obtained from the sphericity test of Bartlett KMO (.859),* $X^2_{calculated,}$ *539.612 with 10 df >* $X^2_{tabulated}$*, Sig. 0.00 < p 0.01, MSA (MATH-CONFI .853; MATH-MOTI .884; MATH-ENGA .846; COMPU-CONFI .868 and INTE-MACO .848) allow us to know that the variables of Galbraith and Haines' scale help us to understand the student's attitude toward mathematics and technology*.

KEYWORDS: Mathematics Confidence, Mathematics Motivation, Computer Confidence, Computer and Mathematics Interaction and Mathematics Engagement.

INTRODUCTION

Nowadays the process of teaching and learning mathematics has been modified by the information technologies through one of its instruments: the computer. This has led to a growing interest in knowing if through this tool, could overcomes some attitudinal deficiencies and with this, to achieve a better student learning. Although there have been many enthusiastic claims for the positive impact of technology on teaching and learning mathematics, it is also certain, that it has been very difficult to achieve systematic evaluations about it (Galbraith and Hines, 1998).

About attitudinal deficiencies, these could be: sensitivity, independence, tolerance and curiosity toward learning mathematics; the sensitivity towards the problem to solve is a creative student characteristic factor, is what led him to seek, investigate and inquire. This sensitivity is linked to a disposition of openness towards the approaches in the teaching process Involves deep knowledge and use of the senses and perception, in order to discover new ways of learning in mathematics. In general the creative student distrusts the established, see failures, problems or deficiencies in their environment.

Curiosity is one of the most important attitudes, because the student is creative to the extent that it is curious. Curiosity is the factor that causes concern in the student and leads to finding solutions to mathematical problems. Regarding tolerance, this attitude leads to respect and the consideration for the opinions and practices of others, i.e., be tolerant to the opinions of classmates and teachers, i.e., having learning readiness, listening other opinions. And finally independence: which represents the ability or faculty to make judgments and decisions necessary to act autonomously in learning mathematics.

However, in the "state of the art" on this issue, some authors have opined on the use of technology in mathematics education, example, Fey (1989) who said:

> *"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" (Fey, 1989).*

In this connection Kaput and Thompson (1994) also warns that the uncritical acceptance of technological inventions which have been created and designed for other audiences (not necessarily for students), lead to difficult alliances or marriages among environments and technologies learning information. This makes it difficult the adaptation of the curriculum, to the technologic innovation (Galbraith and Hines, 1998).

These referential studies do not allow distinguishing between attitudinal and performance aspects specific to mathematics and aspects linked to the technology. However, in the seminal paper of Galbraith and Haines (1998), *"Disentangling the nexus: attitudes to mathematics and technology in a computer learning environment"*, they proposed to make that distinction by disentangling attitudes related to mathematics from those associated with the technology for learning it.

For this reason, it is that emerge several questions such as: What is the attitude of students towards the use of computers in teaching mathematics? What is the attitude of students towards mathematics confidence, motivation and commitment? How is this interaction between the computer and mathematics obtained in the teaching process? These specific questions lead us to pose the main question of the study as follows: Which is the set of latent variables that help understand the student's attitude toward mathematics and technology? To answer this great question, has been raised as a general objective of the study: Identifying the set of latent variables which allow understanding the student's attitude toward mathematics and technology. From there, the null hypothesis is: Ho: There are no factors That Contribute to understand the students' attitude towards mathematics and technology.

For this object of study, we taken as reference seminal theoretical and the scale proposed by Galbraith and Haines (1998), which includes the items: mathematics confidence, motivation mathematics, computer confidence, computer motivation, computer-mathematics interaction and mathematics engagement.

THEORETICAL APPROACH TO ATTITUDE TOWARD MATHEMATICS AND TECHNOLOGY

This research takes the construct proposed by Galbraith and Haines (1998) on the "mathematics-computer" and mathematics-computing attitude in mathematics confidence, computer confidence and computer-mathematics interaction. In additional way, also we take the construct proposed by Cretchley, Harman, Ellerton and Fogarty (2000) about attitudes towards the use of technology for learning mathematics.

Karadag and McDougall (2008) indicate that despite the theoretical and practical concerns in integrating technology into mathematics education, students widely use technology in their daily life at an increasing rate. Because these students were born in the information age, they are confident enough in using technology and have no idea about a life without technology, such as the Internet and computer.

There is no doubt that they are able to use technology effectively, and many studies prove that they use technology as anticipated (Lagrange, 1999; Artigue, 2002; Izydorczak, 2003; Karadag and McDougall, 2008; Kieran, 2007; Kieran and Drijvers, 2006; Moreno-Armella and Santos-Trigo, 2004; Moyer, Niexgoda, and Stanley, 2005). Galbraith (2006) describes the use of "technology as an extension of oneself" as "the partnership between technology and student merge to a single identity" which is the highest intellectual way to use technology.

This use of technology extends the user's mental thinking and cognitive abilities because technology acts as a part of the user's mind. For example, linked representation (Kaput, 1992) between symbolic and visual representation could be a relevant example for this kind of use because manipulations (is) one of the representations that affect the others. For example, linked representation (Kaput, 1992) between symbolic and visual representation could be a relevant example for this kind of use because manipulations is one of the representations that affect the others.

Suurtamm and Graves (2007) state that, "*enabling easier communication, providing opportunities to investigate and explore mathematical concepts, and engaging learners with* *different representational systems which help them see mathematical ideas in different ways"*. They refer to the Ontario Ministry of Education which outlined the use of technology by suggesting: "students can use calculators and computers to extend their capacity to investigate and analyse mathematical concepts and to reduce the time they might need otherwise spent on purely mechanical activities," and added that technology is conceived as a tool to extend students' abilities with tasks which are challenging or impossible in paper-and-pencil environments.

These tasks could be to perform complicated arithmetic operations. In this sense and following the purpose of the study, it is important explain the particular view of mathematics computing attitude; hence, we describe an operational definition of each of dimensions of: Mathematics attitude; Computer attitude; Computer and mathematics interaction and Engagement in learning mathematics of Galbraith and Haines scale:

In order to a greater understanding about the dimensions listed above, and considering as the field academic motivation would question the conceptual distinction between math "confidence" and math "motivation", it is important to point out the explicit operational definition of each of these used dimensions because different intellectual traditions have given rise to various motivation theories and, as a consequence, a number of conceptually distinct motivation constructs have been identified.

Thus, motivation theories have distinct perspectives, which can include focusing on beliefs, values, and goals. This field generally agrees that examining a broad construct of "motivation" is not productive, but rather research should focus on specific constructs within motivation.

The scales designed by Galbraith and Haines (1998) were constructed to parallel components of the Fennema and Sherman (1976) attitude scale but designed to be suitable for undergraduates students. There are five constructs which constitute the scale in which each scale section is composed by eight indicators (see figure 1). About Mathematics confidence and mathematics motivation: in words of Galbraith and Hines, they point out:

> *"Mathematics confidence: Students with high mathematics confidence believe they obtain value for effort, do not worry about learning hard 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 that all mathematics will be difficult, feel that they are naturally weak at mathematics, and worry more about mathematics than any other subject"….* And *"Mathematics motivation: Students with high mathematics motivation, enjoy doing mathematics, stick at problems until they are solved, continue to think about puzzling ideas outside class, and become absorbed in their mathematical activities. Those with low motivation do not enjoy challenging mathematics, are frustrated by having to spend time on problems, prefer to be given answers rather than left with a puzzle, and cannot understand people who are enthusiastic about mathematics" (op cit. 1998)*

In the same sense, the foundations about computer; in the specific case, Computer attitude scales were designed to parallel the corresponding mathematics scales.

Computer Confidence: Students who demonstrate a high confidence in the computer, believe they can dominate necessary software procedures, they also feel more confident in their answers when they do the calculation in computer equipment, hence we are confident solve the problem themselves. Otherwise, students with low computer confidence, they feel at a disadvantage to have to use the computers, feel anxious to use the computer to perform calculations within their teaching process, in short, are not confident on computers to produce correct answers, and panic brings them to make mistakes when using a computer program.

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

Regarding the computer and interaction with mathematics, has had some importance the interaction that exists between these two elements. The importance of this interactive process of learning and context has been studied by different authors among which may be mentioned the works of Lester, Garofalo and Kroll (1989), McLeod (1985) and McLeod (1989b) have concluded that when the technology is not familiar with the student may cause special difficulties. Given the importance of this interaction, authors such as Reif (1987), Chi et al (1989), and Anderson (1995) have pointed out that to the extent the student interacts with the learning materials, such as pen, paper and computer screen, then the human brain adds a dimension to the cognitive processes in student learning.

About “Engagement in learning mathematics”: Regarding this dimension we can point some studies that have contributed to understanding this phenomenon, which reveal the commitment in the learning of mathematics by students, gives results very effective and valuable. Has been shown which some experts effectively used and applied some mechanical concepts in mathematics teaching (Reif, 1987): Likewise other studies have illustrated how through the examples they can build a a powerful framework for learning (Reder et al, 1986; LeFavre and Dixon, 1986). Students learning committed to generate more ideas than students who are not (Chi et al., 1989).

Meanwhile Swing and Peterson (1988) showed that in processes of integration and elaboration as would be in the analysis, defining and compare are related to a greater understanding. Another study conducted by, Reder and Anderson (1980) demonstrated that the summaries supports effective learning. Anderson (1995) has shown that when these factors are frequently associated with the concepts within the learning process, the information received by the student, is more readily remember; also whether all of this information is interconnected in a knowledge network may lead to best results for the student.

In summary we can say about the engagement towards mathematics: Students who scored high on this scale prefer working through examples instead of learning with the given material, and

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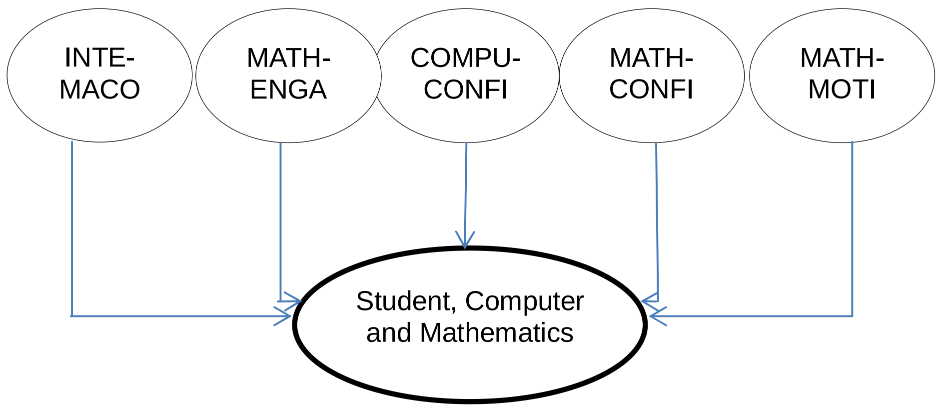
vice versa, students with a low score on this scale prefer learning with the material given to them instead of working through examples.

The above discussion allows us to identify the variables implied in object of study, as illustrated in the following construct which describes the variables proposed by Galbraith and Haines (1998) about: math confidence, math motivation, math engagement, computer confidence and the interaction among math and computer, all this in the trilogy: student, computer and mathematics.

Figure 1 Theoretical Path Model
Student Attitude toward Computer and Mathematics



EMPIRICAL STUDIES

About attitude toward mathematics or statistics, Gal & Garfield (1997), point out that represent a summation of emotions and feelings experienced over time in the context of learning mathematics or statistics. They are quite stable with moderate intensity, and have a smaller cognitive component than beliefs. Attitudes are expressed along a positive-negative continuum (like-dislike, pleasant-unpleasant). Some surveys on attitudes toward mathematics have been undertaken and have developed significantly in the past few years.

The first ones focused on possible relationships between positive attitude and achievement (Leder, 1985), surveys highlighting several problems linked to measuring attitude (Kulm, 1980), a meta-analysis, and recent studies which question the very nature of attitude (Ruffell et al., 1998), or search for ‘good’ definitions (Di Martino and Zan, 2001, 2002), or explore observation instruments that are very different from those traditionally used, such as questionnaires (Hannula, 2002).

It is important to point out that the surveys on attitude towards mathematics have been undertaken for many years, but the studies related to attitude towards information technology has a shorter history in topics about mathematics education. The studies carried out within undergraduate programs in mathematics by Galbraith and Haines (2000) are important for this

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subject matter. In 1998, these authors developed instruments and several attitude scales to measure mathematics and Information Technology attitudes.

These instruments have been used to assess attitudes in different countries: England (e.g. Galbraith and Haines, 1998 and 2000), Australia (e. g. Cretchley and Galbraith, 2002), Venezuela (e.g. Camacho and Depool, 2002), Mexico (e.g. García-Santillán, Flores, Escalera, Chong and López, 2012; García-Santillán, Escalera and Córdova, 2012; García-Santillán, Escalera, Camarena, and García, 2012).

The results offered evidence about several of the attitudes dimensions: 1) mathematics confidence, 2) mathematics motivation, 3) computer confidence, 4) computer and mathematics interaction and 5) mathematics engagement. In all these studies, the authors' findings have been similar: there is a weak relationship between mathematics and computer attitudes (both confidence and motivation) (Di and Zan, 2001) and that students' attitudes to use technology in the learning of mathematics correlate far more strongly with their computer attitudes than with their mathematics attitudes (Cretchley and Galbraith, 2002).

A study conducted by Fogarty, Cretchley, Harman, Ellerton, and Konki (2001), reports on the validation of a questionnaire designed to measure general mathematics confidence, general confidence with using technology, and attitudes towards the use of technology for mathematics learning. A questionnaire was administered to 164 students commencing a tertiary level course on linear algebra and calculus. Scales formed on the basis of factor analysis demonstrated high internal consistency reliability and divergent validity.

A repeat analysis confirmed the earlier psychometric findings as well as establishing good test-retest reliability. The resulting instrument can be used to measure attitudinal factors that mediate the effective use of technology in mathematics learning.

Gómez-Chacón and Haines, (2008) indicate that there are several studies describing the positive impact of technology on students' performance (Artigue, 2002; Noss, 2002). In particular, some researchers underline the new cognitive and affective demands on students in technology programs (Galbraith, 2006; Pierce and Stacey, 2004; Tofaridou, 2007). This evidence suggests that it is important to undertake research topics, which make a careful study of the dialectic aspects of technical and conceptual work, and of the attitudes towards mathematics and technology in the setting where the learning of mathematics uses technology (graphing calculators, computer-based resources).

The results offered evidence about several dimensions of attitudes: mathematics confidence, mathematics motivation, mathematics engagement, computer confidence, computer motivation and mathematics-computer interaction. The authors of these studies get to a similar conclusion, that 'there is a weak relationship between mathematics and computer attitudes (both confidence and motivation) and that students' attitudes towards using technology in the learning of mathematics, correlate far more strongly with their computer attitudes than with their mathematics attitudes' (Cretchley and Galbraith, 2002).

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On the other hand, studies by Goldenberg (2003), Moursund (2003), García and Edel (2008), García-Santillán, Escalera and Edel (2011), García-Santillán and Escalera (2011) report that at present the teaching-learning processes are favourably influenced in the evolution and growth of ICT, which contributes significantly to the educational process of mathematics in general.

Regarding the use of technology to support the teaching process, Crespo (1997), cited in Poveda and Gamboa (2007), claimed that even though "buying and selling" the idea that technology is the magic formula that will transform classrooms into an authentic, perfect teaching and learning setting, in reality this is not true.

However, Gomez Meza (2007), cited by Poveda and Gamboa, (2007), indicates that although technology is not the magic formula, nor probably the solution to all educational problems, it is true that technology could be an agent of change that favours the mathematics teaching-learning process. With these arguments, the hypotheses to be proved are:

Hypothesis

Null Hypothesis H_O: There are no factors that contribute to understand the students' attitude towards mathematics and technology.

Alternative Hypothesis H_1: There are factors that contribute to understand the students' attitude towards mathematics and technology.

METHODS

Sample

The population was delimited to students majoring in: business and management, mechatronic engineering, industrial engineering, strategic system engineering and mechanic engineering who have studied the subject of financial mathematics at the *Universidad Politécnica de Aguascalientes* (UPA).

The type of sampling it is conventional. The sample obtained was of 164 students. Some demographic information on the participants (such as gender, precedency, age) it can see in table 1

Table 1 Composition of the population studied (UPA)

Variable	**%**
Gender	
Male	44.2
Female	55.8
Procedency	
Aguascalientes	85
Others municipals	15
Majoring	

Business and Management	27
Mechatronic engineering	18
Industrial engineering	18
Strategic system engineering	18
Mechanic engineering	18
Age (years)	Minimum 18 y Maximum 23

Source: own

Instrument

We used the questionnaire of Galbraith and Haines (1998), which consists of 5 sections: confidence toward mathematics, mathematics motivation, engagement mathematics, the computer confidence, computer and mathematics interaction (see appendix 1).
Each section consists of 8 item measured on a Lickert scale: Mathematics Confidence (items 1 to 8), Mathematics Motivation (items 9 to 16), Mathematics Engagement (items 17 to 24), Computer confidence (items 25 to 32) and Computer-Mathematics Interaction (items 33 to 40). This scale ranged from 1 (low) to 5 (very high). Therefore, in order to determine the reliability of instrument was used the Cronbach alpha method. The result obtained was 0.904 (grouped variables) and 0.902 (separated variables). We can see that the reliability of instrument is more than 0.6, so we can say that the instrument applied provides the features of reliability and consistency (Hair, 1999).

Procedure

The statistical procedure used was factorial analysis with an extracted principal component. Statistics test to prove: χ^2, Bartlett's test of sphericity, KMO (Kaiser-Meyer_Olkin) Significance level: α=0.01; $p< 0.01$, $p<0.05$ Decision rule: Reject Ho if χ^2 calculated > χ^2 tables.

RESULTS AND DISCUSSION

The empirical research was supported by the statistical technique of factorial analysis for testing the factors that contribute to the students' attitudes towards mathematics and technology. Table 2 shows the correlation among variables are all meaningful (>.5 sig. <0.01).

Table 2 Correlations Matrix

	Variables	COMPU-CONFI	MATH-MOTI	MATH-ENGA	INTE-MACO	MATH-CONFI
	COMPU-CONFI	1.000				
Correlation	MATH-MOTI	.624	1.000			
	MATH-ENGA	**.734**	.627	1.000		
	INTE-MACO	**.749**	.623	**.785**	1.000	
	MATH-CONFI	.676	.668	.569	.594	1.000

Sig. (Unilateral)	COMPU-CONFI					
	MATH-MOTI	.000				
	MATH-ENGA	.000	.000			
	INTE-MACO	.000	.000	.000		
	MATH-CONFI	.000	.000	.000	.000	

Bartlett's test of Sphericity 539.612 (α=0.00) df 10
Measure of sampling adequacy (overall) (KMO) 0.859
a. Determinant = .035

Source: own

The contrast values of Bartlett's test allow us to say that the correlation matrix is significance (α=0.00) when taken all variables (table 2). The measure of overall sampling adequacy (overall) (KMO) is 0.859 which's acceptable (>0.50). The examination of the values of each variable identifies that all variables have values greater than 0.5, table 3 shows the measures sample adequacy for each variable (MSA).

Table 3 Measure of sampling adequacy (MSA)

Variable	COMPU-CONFI	MATH-MOTI	MATH-ENGA	INTE-MACO	MATH-CONFI
COMPU-CONFI	.868[a]				
MATH-MOTI	-.063	.884[a]			
MATH-ENGA	-.283	-.191	.846[a]		
INTE-MACO	-.314	-.127	-.474	.848[a]	
MATH-CONFI	-.336	-.395	.020	-.062	.853[a]

Source: own

Table 4 denominated component matrix and communalities, shows just one factor that incorporates five variables and their explanatory power expressed by its eigenvalues (3.664). The values in the first column reflect the factor loadings of each variable and the second column reveals how each variable is explained by the components. Thus, we can see that the greatest weight variable is COMPU-CONFI (computer confidence) followed by the INTE-MACO (interaction between the computer and mathematics), and MATH-ENGA (mathematics engagement) and with the lowest weight is the MATH-CONFI (mathematics confidence) followed by the MATH-MOTI (mathematics motivation).

Table 4 Component Matrix and Communalities

	Component 1	Communalities
COMPU-CONFI	.887	.799
MATH-MOTI	.823	.794
MATH-ENGA	.872	.868
INTE-MACO	.881	.867
MATH-CONFI	.814	.867

Eigenvalues	3.664
% Total variance	73.279

Source: own

Also, we can see in Table 4 that the variables COMPU-CONFI (computer confidence) followed by the variable INTE-MACO (interaction between the computer and mathematics), which have been considered to examine the impact of technology on the attitude towards mathematics, show a substantially good factorial weight (0.887 and 0.871 respectively). The remaining variables that measure MATH-CONFI followed by the MATH-MOTI and also are considered to measure the influence attitude toward mathematics, show a good factorial weight (0.823 and 0.814) and the highest communalities are: MATH-ENGA (0.868) INTE-MACO (.867) MATH-CONFI (0.867). These results are statistically significant and practical because the 73.27%, indicates that students attitude toward mathematics and technology may be explained by the proposed variables and sample size.

CONCLUSION

This paper shows how mathematics confidence, motivation mathematics, computer confidence, computer motivation, computer-mathematics interaction and mathematics engagement help to understand the students' attitude toward mathematics and technology. The findings are consistent with other authors (García-Santillán, Escalera and Edel 2011, García-Santillán and Escalera, 2011) which reveal that the presence of technology encourages the learning process of mathematics.

Another study performed at a public university (UASLP), Garcia-Santillán, Flores, Escalera, Chong and Lopez (2012) showed that the motivating factor toward mathematics and confidence toward computers, are the main factors contributing to explanation of the phenomenon of study.

It is also important to point out, the results of the research have a theoretical implication because allows to support the theoretical foundation proposed by Galbraith and Haines (1998). The constructs regarded by the authors are statistical and practical significance on students who have been the subject of this study.

Also, the evidence obtained in this work, contributes to predict the reality described by the authors, regarding the attitude toward mathematics and simultaneously gives light to establish new questions to promote the search for new knowledge.

At the same time the practical implications are due to the results are useful for higher education institutions to perform teaching strategies focused on the use of information technologies. It is important to carry out a greater effort for the teachers which teach the subject (and not using this tool) motivate them to use these technological tools in such a way them to go increasingly adapting in order to strengthen the student's attitude toward mathematics.

LIMITATIONS AND FURTHER RESEARCH

This research is limited to only one sector of public university students, therefore, it is important to develop future research that considers other public and private universities and compare if the attitude toward mathematics is different with respect to the university or gender where they belong or the career they have chosen. In addition it is important to know if these differences may vary in relation to the variables studied, therefore it is recommended replicate this study to learn about and contribute (support) to the theories related to attitude toward mathematics and technology.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

AUTHORS' CONTRIBUTIONS

Authors may use the following wordings for this section: "'Author A' designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. 'Author B' and 'Author C' managed the analyses of the study. 'Author C' managed the literature searches…… All authors read and approved the final manuscript."

CONSENT (WHERE EVER APPLICABLE)

All authors declare that 'written informed consent was obtained from the patient (or other approved parties) for publication of this case report and accompanying images. A copy of the written consent is available for review by the Editorial office/Chief Editor/Editorial Board members of this journal."

REFERENCES

Anderson, J. R.: (1995), Cognitive Psychology and Its Implications, (4th. ed.), New York: W. H. Freeman and Company.

Artigue, M. (2002). Learning mathematics in a CAS environment: The genesis of a reflection about instrumentation and the dialectics between technical and conceptual work. *International Journal of Computers for Mathematical Learning, 7,* 245-274.

Camacho, M. & Depool, R. (2002). Students' attitudes towards mathematics and computers when using derive in the learning of calculus concepts. *The International Journal of Computer Algebra in Mathematics Education, 9 (4)*, 259-283.

Chi, M. T. H., Lewis, M. W., Reimann, P. and Glaser, R.: 1989, 'Self explanations: how students study and use examples in learning to solve problems', Cognitive Science 13, 145–182.

Cretchley, P. & Galbraith, P. (2002). Mathematics or computers? Confidence or motivation? How do these relate to achievement? *Proceedings 2nd International Conference on the Teaching of Mathematics (Undergrad),* , CD and online, Wiley, Crete.

Di, M. & Zan, R. (2001). Attitude toward mathematics: Some Theoretical issues. *Proceedings of PME 25 (Utrecht, Netherlands), vol. 3,* 351-358.

Fennema, E. & Sherman, J. A. (1976). Fennema-Sherman Mathematics Attitudes 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

Fey, J. T.: 1989, 'Technology and Mathematics Education: A survey of recent developments and important problems', *Educational Studies in Mathematics 20*, 237–272.

Fogarty, G., Cretchley, P., Harman, C., Ellerton, N. & Konki, N. (2001).Validation of a Questionnaire to Measure Mathematics Confidence, Computer Confidence, and Attitudes towards the Use of Technology for Learning Mathematics. *Mathematics Education Research Journal*, 13, (2), 154-160.

Galbraith, P. (2006).Students, mathematics, and technology: assessing the present challenging the future, *International Journal of Mathematical Education in Science and Technology*, 37, (3), 277-290.

Galbraith, P. & Haines, C. (1998). Disentangling the nexus: Attitudes to mathematics and technology in a computer learning environment. *Educational Studies in Mathematics 36*, 275-290.

Galbraith, P., Haines, C. & Pemberton, M. (1999). A tale of two cities: When mathematics, computers, and students meet. In J. M. Truran & K. M. Truran (Eds.),*Making a difference* (Proceedings of the 22nd annual conference of the Mathematics Education Research Group of Australasia, Adelaide, pp. 215–222). Sydney: MERGA.

Galbraith, P. & Haines, C. (2000). Mathematics-computing Attitudes Scales. Monographs in Continuing Education. London: City University.

Garcia-Santillán, A. & Edel, R. (2008). Education-learning of the financial mathematics from the computer science platforms (Simulation with ICT). Main Theme: Application of ICT (information and communications technologies), in education-learning process. Annual Meeting Nova Southeastern University "Beyond the Classroom" Fischler School of Education & Human Service. NOVA EDUC@2008. March 17-19, 2008. Miami Beach, Florida USA.

García-Santillán, A. & Escalera, M. (2011). IT applications as a didactic tool in the teaching of math's (using of spreadsheet to programming) *Journal of Knowledge Management, Economics and Information Technology,* I, (6), 122-138.

García-Santillán, A., Escalera M. & Edel, R. (2011).Associated variables with the use of ICT as a didactic strategy in teaching-learning process of financial mathematics. An experience from the classroom. *Revista Iberoamericana de Evaluación Educativa*, 4 (2), 118-135.

García-Santillán, A.; Flores-Zambada, R.; Escalera, M.; Chong, I. and López, S (2012): Students, computers and mathematics. How do they interact in the teaching-learning process? Empirical study on accounting, management and marketing undergraduate students. *International Journal of Learning and Development Vol. 2, Issue 2 pp.177-200.*

García-Santillán, A.; Escalera, M.; and Córdova, A.; (2012). Variables to measure interaction among mathematics and computer through structural equation modeling. *Journal of Applied Mathematics and Bioinformatics Vol 2, No. 3 pp 51-6.*

García-Santillán, A.; Escalera, M.; Camarena, P. & García, A. (2012). Structural equations modeling to measure variables involved in the interaction between mathematics and computer: an empirical study in undergraduate students. *International Journal of Humanities and Social Science Vol 2, No. 24 special issue December 2012 pp 6-13.*

Gómez, D. (1998). Tecnología y educación matemática. Revista Informática Educativa, 10 (1). Colombia.

Gómez-Chacón, M. I., & Haines, C. (2008). Studentes' attitudes to mathematics and technology. Comparative study between the United Kingdom and Spain . *International Congress on Mathematical Education*, 1-12.

Hair**,** J. F. Jr.; Anderson, R. E.; Taltham, R. L. Y Black, W. C. (1999). *Análisis multivariante.* 5a. Edición. Madrid: Prentice Hall.

Hannula, M., Evans, J., Philippou, G., & Zan, R. (2004). Affect in mathematics education-exploring theoretical framework. Procceding of PME 28 (Bergen, NW) 1, 107.136.

Izydorczak, A. E. (2003). *A Study of Virtual Manipulatives for Elementary Mathematics*. Unpublished doctoral dissertation, State University of New York, Buffalo, New York.

Kaput, J. J. & Thompson, P. W. (1992). Technology and Mathematics Education. En D. A. Grouws, *Handbook of Research on Mathematics Teaching and Learning* (págs. 515-556). New York: Macmillan.

Kaput, J. J. (1994). Technology in Mathematics Education Research: The first 25 years in the JRME. *Journal of Research into Mathematics Education,*25,(6), 676-684.

Karadag, Z. & McDougall, D. (2008). Studying mathematical thinking in an online environment: Students‟ voice. In Figueras, O. & Sepúlveda, A. (Eds.), *Proceedings of the Joint Meeting of the 32nd Conference of the International Group for the Psychology of Mathematics Education, and the XXX North American Chapter 1*, 350. Morelia, Michoacán, México: PME.

Kieran, C. & Drijvers, P. (2006). The co-emergence of machine techniques, paper-and-pencil techniques, and theoretical reflection: A study of CAS use in secondary school algebra. *International Journal of Computers from Mathematical Learning, 11*, 205-263.

Kieran, C. (2007). Interpreting and assessing the answers given by the CAS expert: A reaction paper. *The International Journal for Technology in Mathematics Education*, *14*(2), 103-107.

Kulm, G. (1980). Research on Mathematics Attitude, in R.J. Shumway (ed.). *Research in mathematics education. Reston, VA: National Council of Teachers of Mathematics*.

Lagrange, J. (1999). Complex calculators in the classroom: Theoretical and practical reflections on teaching pre-calculus. *International Journal of Computers for Mathematical Learning, 4,* 51–81.

Leder,G. (1985). Measurement of attitude to mathematics. *For the learning of Mathematics*, 5(3), 18-21.

Lester, F. K., Garofalo, J. and Kroll, D. L.: 1989, 'Self-confidence, interest, beliefs, and metacognition: key influences on problem-solving behavior', in D. B. McLeod and V. M. Adams (eds.), Affect and Mathematical Problem Solving: A New Perspective, pp. 75–88, New York: SpringerVerlag.

McLeod, D. B.: 1985, 'Affective issues in research on teaching mathematical problem solving', in E.A.Silver (eds.), Teaching and learning mathematical problem solving: Multiple research perspectives, pp. 267–279, Hillsdale, N. J.: Lawrence Erlbaum Associates.

McLeod, D. B.: 1989a, ‘Beliefs, attitudes and emotions: new views of affect in mathematics education’, in D. B. McLeod and V. M. Adams (eds.), Affect and Mathematical Problem Solving: A New Perspective, pp. 245–258, New York: Springer Verlag.

McLeod, D. B.: 1989b, ‘The role of affect in mathematical problem solving’, in D. B. McLeod and V. M. Adams (eds.), Affect and Mathematical Problem Solving: A New Perspective, pp. 20–36, New York: Springer Verlag.

Moreno-Armella, L. & Santos-Trigo, M. (2004). Students‟ exploration of powerful mathematical ideas through the use of algebraic calculators. In D. E. McDougall & J. A. Ross (Eds.), *Proceedings of the twenty-sixth annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education*, *1*, 135-142. Toronto: OISE/UT.

Moreno-Armella, L., Hegedus, S. J. & Kaput, J. J. (2008). From static to dynamic mathematics: Historical and representational perspectives. *Educational Studies in Mathematics,* 68, 99-111.

Moursund, David (s/f). Editorial: The Spreadsheet. *Revista Learning £Leading with Technology*, 26 (5) disponible en http://www.iste.org/LL/

Moyer, P.S., Niexgoda, D., & Stanley, J. (2005). Young Children‟s Use of Virtual Manipulative and Other Forms of Mathematical Representations. In W. J. Masalski & P. C. Elliot (Eds.), *Technology-Supported Mathematics Learning Environment*. Reston, VA: The National Council of Teachers of Mathematics.

Noss, R. (2002). For a learnable mathematics in the digital culture. *Educational Studies in Mathematics,* 48, 21-46.

Pierce, R & Stacey, K. (2004). A Framework for Monitoring Progress and Planning Teaching Towards the Effective Use of Computer Algebra Systems. *International Journal of Computers for Mathematical Learning*, 9, (1), 59-93.

Poveda, R. y Gamboa R. (2007). Consideraciones, características, limitaciones y clasificación de una clase basada en talleres. UNA Costa Rica. Recuperado de: http://cimm.ucr.ac.cr/cuadernos/cuaderno3.php.

Reder, L. M. and Anderson, J. R.: 1980, ‘A comparison of texts and their summaries: Memorial consequences’, Journal of Verbal Learning and Verbal Behaviour 19, 121– 134

Reif, F.: 1987, ‘Interpretation of scientific or mathematical concepts: Cognitive issues and instrumental implications’, Cognitive Science 11, 395–416.

Ruffell,M., Mason, J, & Allen, B.(1998). ‘Studying attitude to mathematics’, *Educational Studies in Mathematics*, 35(1), 1–18.

Suurtamm, C. & Graves, B. (2007). *Curriculum implementation in intermediate math (CIIM): Research report*. Canada: Faculty of Education, University of Ottowa. Retrieved April 15, 2008, from http://www.edu.gov.on.ca/eng/studentsuccess/lms/.

Swing, J. and Peterson, P.: 1988, ‘Elaborative and Integrative Thought Processes in Mathematics Learning’, Journal of Educational Psychology 80(1), 54–66.

Tofaridou, I.(2007). Learning Styles and Technology Environments in mathematics. Education, Ph.D. Thesis, City University, London, 286

Gal, I. & Garfield, J. B. (1997). The Assessment Challenge in Statistics Education. IOS 37-51. ISBN 90 5199 333 1. Press, 1997 (on behalf of the ISI). Pages 37-51. ISBN 90 5199 333 1. Copyright holder: International. The References section is a separate chapter and is available on the Internet at http://www.stat.auckland.ac.nz/~iase/publications/assessbkref

APPENDIX

Attitude scales toward: maths confidence, computer confidence, maths-tech attitudes, maths-tech experience (Galbraith, P. & Haines, C. 1998-2000).

Mathematics Confidence	Lowest 1	Low 2	Neutral 3	High 4	Highest 5
1.- Mathematics is a subject in which I get value for effort					
2.- The prospect of having to learn new mathematics makes me nervous					
3.- I can get good results in mathematics					
4.- I am more worried about mathematics than any other subject					
5.- Having to learn difficult topics in mathematics does not worry me					
6.- No matter how much I study, mathematics is always difficult for me					
7.- I am not naturally good at mathematics					
8.- I have a lot of confidence when it comes to mathematics.					
Mathematics Motivation	Lowest 1	Low 2	Neutral 3	High 4	Highest 5
9.- Mathematics is a subject I enjoy doing					
10.- Having to spend a lot time on a mathematics problem frustrates me					
11.- I don’t understand how some people can get so enthusiastic about doing mathematics					
12.- I can become completely absorbed doing mathematics problems					
13.- If something about mathematics puzzles me, I would rather be given the answer than have to work it out myself					
14- I like to stick at a mathematics problem until I get it out					
15.- The defy of understanding mathematics does not appeal to me					
16.- If something about mathematics puzzles me, I find myself find about it afterwards.					
Mathematics Engagement	Lowest 1	Low 2	Neutral 3	High 4	Highest 5

17.- I prefer to work with symbols (algebra) than with pictures (diagrams and graphs)					
18.- I prefer to work on my own than in a group					
19.- I find working through examples less effective than memorizing given material					
20.- I find it helpful to test understanding by attempting exercises and Problems					
21.- When studying mathematics I try to link new ideas or knowledge I already have					
22.- When learning new mathematical material I make notes to help me understand and remember					
23.- I like to revise topics all at once rather than space out my study					
24.- I do not usually make time to check my own working to find and correct errors					
Computer confidence	Lowest 1	Low 2	Neutral 3	High 4	Highest 5
25.- As a male/female (cross out which does not apply) I feel disadvantage in having to use computers					
26.- I have a lot of self-confidence in using computers					
27.- I feel more confident of my answers with a computer to help me					
28.- If a computer program I am using goes wrong, I panic					
29.- I feel nervous when I have to learn new procedures on a computer					
30.- I am confident that I can master any computer procedure that is needed for my course					
31.- I do not trust myself to get the right answer using a computer					
32.- If I make a mistake when using a computer I am usually able to work out what to do for myself					
Computer-Mathematics Interaction	Lowest 1	Low 2	Neutral 3	High 4	Highest 5
33.- Computers help me to learn better by providing many examples to work through					
34.- I find it difficult to transfer understanding from a computer screen to my head					

35.- By looking after messy calculations, computers make it easier to learn essential ideas					
36.- When I read a computer screen, I tend to gloss over the details of the mathematics					
37.- I find it helpful to make notes in addition to copying material from the screen, or obtaining a printout					
38.- I rarely review the material soon after a computer session is finished					
39.- Following keyboard instructions takes my attention away from the mathematics					
40.- Computers help me to link knowledge e.g. the shapes of graphs and their equations					