Student's attitude toward Computer and Mathematics, Interaction and Engagement in the teaching-learning process: Empirical study on Accounting, Management, Economy, International Commerce and Marketing undergraduate students

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Abstract

The study takes the scale proposed by Galbraith and Hines (1998), about Mathematics confidence, Mathematics motivation, Computer confidence, Computer motivation, Computer and Mathematics interaction and Mathematics engagement. A total of 303 questionnaires were applied to undergraduate students in Accounting, Management, Economy, International Commerce and Marketing. The statistical procedure was the factorial analysis with extracted principal component. The Hypothesis: Ho: $\rho = 0$ has no correlation Ha: $\rho \neq 0$ have correlation. The results obtained by the Kaiser-Meyer-Olkin (KMO) and Bartlett's test of shpericity ($\chi^2_{calculated}$) 92.902 > χ^2_{tables}, Sig. 0.00 $p< 0.01$ KMO 0.668; Measure sample adecuacy (MSA): (CONFIMA 0.682; MOTIMA 0.639; COMPROMA 0.716; CONFICOM 0.688 and INTEMACO 0.660) provide evidence to reject the nul hypothesis (Ho). Thus, the variables implicated Mathematics confidence, Mathematics motivation, Computer confidence, Computer motivation, Computer-Mathematics interaction and Mathematics engagement; help understand the student's attitude toward mathematics and technology.

Keywords: Mathematics confidence, Mathematics motivation, Computer confidence, Computer motivation, Computer and Mathematics interaction, Mathematics engagement

1. Introduction

In Galbraith`s words *et al* "When students, computer and mathematics meet, *make a difference?* In the seminal paper of Galbraith and Hines (1998) *"Disentangling the nexus: attitudes to mathematics and technology in a computer learning environment"* they refer that, gaining insights into students' attitudes and beliefs is the most important and crucial step in understanding how the learning environment for mathematics is affected by the introduction of computers and other technology. In this sense, they report on the application of six Galbraith–Haines scales applied to 156 students in the entry courses of engineering and actuarial science. In this research they discuss the implications of confidence, motivation, engagement and the interaction with technology in the learning process and they demonstrate that the computer and mathematics attitude scales capture distinctive properties of student behavior in this respect.

Therefore some questions emerged in this research: *What's the students' attitude toward the use of computer in the teaching of mathematics? What's the student' attitude toward mathematics confidence, motivation and engagement? And how is the interaction between computer and mathematics in the teaching process?* In order to answer these questions, the objective of this study is to measure, how Mathematics confidence, Mathematics motivation, Computer confidence, Computer motivation, Computer-Mathematics interaction and Mathematics engagement, help understand the students' attitude toward mathematics and technology.

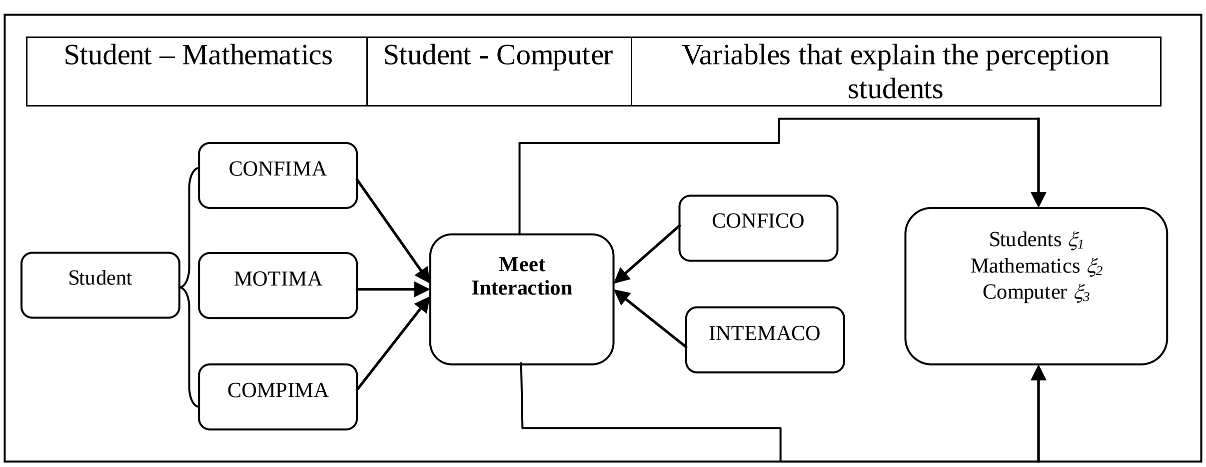
2. Theoretical approach

Some studies on attitude towards mathematics have been developed in recent decades. From the first studies that focused on the relationship between positive attitudes and achievement (Leder, 1985), to studies that highlight various issues relating to measuring of attitude (Kulm, 1980, Wise, 1985), and other studies that question the very nature of the attitude (Ruffell, et al., 1998), and others that look for a "good" definition of attitude (Di Martino y Zan, 2001). It is important to mention that there is no clear evidence on the relationship between attitudes and performance. Some correlated studies confirm the relationship between affective variables and achievement, and some claim to predict achievement (Fennema and Sherman, 1976; Meyer, 1985). Although the study of attitudes towards mathematics has been developing since a long time ago, the study of attitudes towards technology in teaching mathematics has a shorter history. Regarding the studies carried out by Galbraith and Haines (1998), they are relevant since they developed scales to measure students' attitude towards mathematics and the use of information and communication technologies in the teaching of mathematics.

Some studies using these scales to measure attitudes towards mathematics and technology, for example: in England (Galbraith and Haines 1998), Australia (Cretchley and Galbraith, 2002), Venezuela (Camacho and Depool, 2002), whose evidence, have proposed the following dimensions of attitude: confidence in mathematics, mathematics motivation, commitment towards mathematics, computer confidence, motivation in computers and the interaction between mathematics and computers. The authors of these studies reached a similar conclusion, that there is a weak relationship between attitude toward mathematics and computers (both confidence and motivation) and the correlation of the student´s attitude towards the use of technology in learning math is stronger with the attitude towards computer and mathematics (Cretchley and Galbraith, 2002), in this case it is important to ask the following: *What type of interaction is present between attitudes toward mathematics and technology in college students?* It also seeks to find evidence to see whether there are differences between the studies already mentioned and those obtained in this study. Therefore, in this study we take the scale Galbraith and Haines (1998), about Computer aided teaching mathematics.

On the other hand, this research takes the construct proposed by Galbraith, Haines and Pemberton (1999) and Galbraith and Haines (2000), on mathematics-computer and mathematics-computing attitude on mathematics confidence, computer confidence and computer-mathematics interaction. About the attitudes towards the use of technology for learning mathematics, we take the construct proposed by Cretchley, Harman, Ellerton and Fogarty (2000). Finally, as a result of theoretical discussion, we identified the next set of implicated variables, which are shown in the next construct.

Figure 1 Theoretical Path Model



Source: self made

3. Hypothesis

H1: The latent variables Mathematics confidence, Mathematics motivation, Computer confidence, Computer motivation, Computer-Mathematics interaction and Mathematics engagement, help understand the students' attitude toward mathematics and technology.

4. Method

Population and sample

The scale of Galbraith and Hines (1998) was applied to all the groups of students who had taken mathematics courses between the second and third school year, combining ordinary classroom sessions and other practices in the computer laboratory, at Cristobal Colon University (Veracruz-México). Table 1 shows the participants for 6th and 8th semester of an undergraduate-major. After reviewing all the questionnaires, 47 were rejected, thus our sample size are 303 cases.

Table 1. Population at Cristobal Colón University-Veracruz Mexico Economic-Administrative Center

Undergraduate-Major (semesters)	Student`s	Partial	Accumulated	Rejected	Questionnaires Accepted
Economy 6th	16				
Economy 8th	12	28	28	2	26
Accounting 6th	26				
Accounting 8th	33	59	87	17	42
Management 6th	31				
Management 8th	30	61	148	12	49
Market and International Business 6th A	27				
Market and International Business 6th B	29				
Market and International Business 8th A	18				
Market and International Business 8th B	23	97	245	12	85
Marketing 6th.	18				
Marketing 8th	20	38	283	3	35
Tourist Management Enterprises 6th A	19				
Tourist Management Enterprises 6th B	16				
Tourist Management Enterprises 8th	32	67	350	1	66
		Σ	**350**	**47**	**303**

Source: self made

5. Statistical Proceeding

If we considered the follow Hypothesis: Ho: ρ=0 have no corelation Ha: ρ ≠ 0 have correlation. Statistic test to prove: χ^2, y Bartlett's test of sphericity, KMO (Kaiser-Meyer_Olkin). Significancy level: α =0.05; $p < 0.05$ *load factorial of .70* Critic value: χ^2 calculated > χ^2 tables, then reject *Ho* and the decition rule is: Reject *Ho* if χ^2 calculated > χ^2 tables. The statistical procedure to measure data is an exploratory Factorial Analyze Model. Firstly, if we considered the following variables to measure: Attitude scales towards: Mathematics Confidence, Mathematics Motivation, Computer Confidence, Computer Motivation, Computer and Mathematics Interaction, and Mathematics Engagement (Galbraith, & Haines, 1998) all variables are identified as $X_1 \ldots\ldots X_{40}$ (are latent variables ξ_i), all these in order to measure *303* students, then we obtain the following data matrix:

Students	Variables X_1 X_2 . . . . . X_p
1	X_{11} X_{12} …. x_{1p}
2	X_{21} X_{22} …. x_{2p}
…..	……….
303	X_{n1} X_{n2} …. x_{np}

The above mentioned, is given by the equation:

$$X_1 = a_{11}F_1 + a_{12}F_2 + ... + a_{1k}F_k + u_1$$
$$X_2 = a_{21}F_1 + a_{22}F_2 + ... + a_{2k}F_k + u_2$$
$$...$$
$$X_p = a_{p1}F_1 + a_{p2}F_2 + ... + a_{pk}F_k + u_p$$

Where **F_1,... F_k** (K<<p) are common factors and **u_1**, …. **u_p** are specific factors and coefficients $\{a_{ij}; i=1,\ldots,p; j=1,\ldots,k\}$ are factorial loads. Besides, we suppose that the common factor has been standardized ($E(F_i) = 0$; $Var(F_i) = 1$, the specific factors have *0* media and has correlation ($E(u_i) = 0$; $Cov(u_i, u_j) = 0$ if $i \neq j$; j, i = 1, …..,p) and both factors have correlation ($Cov(F_i,u_j) = 0$, $\forall_i = 1,\ldots,k$; j=1,….,p.

Thus, if the factors are correlated ($Cov(F_i,F_j) = 0$, if $i \neq j$; j, i=1,…..,k) then we have a model with orthogonal factors, if not, will have a model with oblique factors.

Therefore, it's expressed the following way: $x = Af + u \Leftrightarrow X = FA' + U$

Where:

It´s the data matrix	It´s factorial load matrix	It´s factorial punctuation matrix
$x = \begin{pmatrix} x_1 \\ x_2 \\ \ldots \\ x_p \end{pmatrix}, f = \begin{pmatrix} F_1 \\ F_2 \\ \ldots \\ F_k \end{pmatrix}, u = \begin{pmatrix} u_1 \\ u_2 \\ \ldots \\ u_p \end{pmatrix}$	$A = \begin{pmatrix} a_{11}a_{12}.....a_{ik} \\ a_{21}a_{22}.....a_{2k} \\ .... \\ a_{p1}a_{p2}.....a_{pk} \end{pmatrix}$	$F = \begin{pmatrix} f_{11}f_{12}.....f_{ik} \\ f_{21}f_{22}.....f_{2k} \\ .... \\ f_{p1}f_{p2}.....f_{pk} \end{pmatrix}$

Using the previously mentioned hypothesis, we have now:

$$Var(X_i) = \sum_{j=1}^{k} a_{ij}^2 + \Psi_i = h_i^2 + \Psi_i; i = 1,\ldots,p$$

Where:

$$h_i^2 = Var\left(\sum_{j=1}^{k} a_{ij}F_j\right) ...y.... \Psi_i = VAr(u_i)$$

This equation, correspond to communalities and the specificity of variable X_i respectively. So the variance of each variable may be divided in two parts: one of their communalities h_i^2 that represents the variance explained by *b* and the common factors and another one, the specificity Ψ_I that represent the specific variance part of each variable.

So, we obtained:

$$Cov(X_i, X_l) = Cov\left(\sum_{j=1}^{k} a_{ij}F_j, \sum_{j=1}^{k} a_{lj}F_j\right) = \sum_{j=1}^{k} a_{ij}a_{lj} \quad \forall i \neq \ell$$

These are common factors that explain the relationship between the studied variables.

Finally, we have the KMO, MSA and Bartlett's test of sphericity. The KMO is an index for comparing the magnitudes of the observed correlation coefficients to the magnitudes of the partial correlation coefficients.

Large values for KMO indicate that a factor analysis of the variables is a good idea. The Kaiser-Meyer-Olkin measure of sampling adequacy tests (MSA) whether the partial correlations among variables are small. If, in the Bartlett's test of sphericity, the correlation matrix is an identity matrix, so, this indicates that the factor model is inappropriate.

Bartlett's test of sphericity is used to test the null hypothesis that the variables in the population correlation matrix are not correlated, so Ho R=1 means that the determinant of correlations matrix is 1. Bartlett's Test of Sphericity is given by:

$$d_R = -\left[n - 1 - \frac{1}{6}\left(2p + 5\right)\ln\left|R\right|\right] = -\left[n - \frac{2p + 11}{6}\right]\sum_{j=1}^{p}\log(\lambda_j)$$

Where:

n = sample size;
ln= neperian logharitm;
λ_j(j=1,…..,p) eigenvalues of R;
R = correlation matrix.

The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Measure of sampling adequacy for each variable (MSA) are given by

$$KMO = \frac{\sum_{j\neq i}\sum_{i\neq j} r_{ij}^2}{\sum_{j\neq i}\sum_{i\neq j} r_{ij}^2 + \sum_{j\neq i}\sum_{i\neq j} r_{ij(p)}^2} \qquad MSA = \frac{\sum_{i\neq j} r_{ij}^2}{\sum_{i\neq j} r_{ij}^2 + \sum_{i\neq j} r_{ij(p)}^2}; i = 1, \ldots, p$$

Where: $r_{ij\,(p)}$ is partial coefficient of correlation between variable X_i and X_j in all cases.

6. *Findings and Discussion*

In order to answer the main question, firstly was validated the test used in the field research data, obtaining the next coefficient Cronbach's alpha (table 2 and 3)

Table 2. Case Processing Summary

		N	%
Cases	Valid	303	100.0
	Excluded [a]	0	0.0
	Total	303	100.0
a. Listwise deletion based on all variables in the procedure.			

Source: self made

Table 3. Reliability Statistics

Cronbach's Alpha	N of Items
0.581	40
0.581= 0.6	

Source: self made

We can observe that the reliability of the instrument is > 0.5 and under the criteria Cronbach's Alpha > 0.6 (Hair, 1999) then we can say that the instrument has the characteristic of consistency and reliability required.

Now, described in Table 4 we show the mean and standard deviation, to determine the coefficient of variation to identify the variables that have more variation with respect to the others that make up the model.

Table 4. Descriptive Statistic

	Mean	Std. Deviation	Analysis N	VC=mean/std
CONFIMA_X1	24.9404	3.92916	303	15.75%
MOTIMA_X2	24.6821	3.36460		13.63%
COMPROMA_X3	25.2914	5.21446		**20.62%**
CONFICOM_X4	25.1589	4.56782		18.16%
INTEMACO_X5	25.8344	3.62518		14.03%

Source: self made

Based on the results described in Table 4, the variable COMPROMA (20.62%) it is showing greater dispersion compared with the rest of the variables which show similar behavior. After capturing the data, and in order to validate whether the statistical technique of factor analysis helps to explain the studied phenomenon, firstly we conducted a contrast from the Bartlett's test of sphericity with Kaiser (KMO Measure), chi square $\chi 2$ and Measure Sample Adequacy (MSA) to determine the correlation between the variables under study and to determine if the technique of factor analysis is applicable here. Table 5 shows the results obtained.

Table 5. Correlation Matrix-KMO, MSA

VARIABLE	correlation	sig	MSA	KMO	χ^2
CONFIMA	0.308	0.000	0.682	0.668	92.902 Df 10
MOTIMA	0.490	0.000	0.639		
COMPROMA	0.253	0.000	0.716		
CONFICOM	0.262	0.000	0.688		
INTEMACO	0.441	0.000	0.660		

Source: self made

Observing the results in Table 5, the statistic KMO has a value of 0.668 which is very close to 1, this indicates that the data is adequate for the factorial analysis and the Bartlett's test of sphericity (X^2 calculated 92.902 with 10 df > X^2*table)* with p-value 0.000 there is significant evidence to reject the null hypothesis (*Ho*) that relates to non-correlation, having found correlation in the test statistic as outlined above, therefore a factor analysis can be made that allows to answer the research question:

RQ1: What is the underlying latent variables structure that allows understanding the students' attitude toward mathematics and technology?

The results obtained from the correlation matrix are shown in Table 6; we observe the behavior of each variable with respect to others. The criteria for determining low correlation is the higher number, lower versus higher determining the correlation, then one can predict the degree of intercorrelation between the variables.

Table 6. Correlation Matrix[a]

		CONFIMA	MOTIMA	COMPROMA	CONFICO	INTEMACO
Correlation	CONFIMA_X1	1.000				
	MOTIMA_X2	0.275	1.000			
	COMPROMA_X3	0.112	0.193	1.000		
	CONFICO_X4	0.104	0.148	0.161	1.000	
	INTEMACO_X5	0.175	0.307	0.148	0.220	1.000
Sig. (1-tailed)	CONFIMA_X1					
	MOTIMA_X2	0.000				
	COMPROMA_X3	0.026	0.000			
	CONFICO_X4	0.035	0.005	0.003		
	INTEMACO_X5	0.001	0.000	0.005	0.000	
a. Determinant = 0,732						

Source: self made

In the above table we see that the determinant is high (0.732) indicating a low degree of intercorrelation between the variables (<0.5) however, it shows a positive correlation, this should be taken with caution when wording the conclusions. Just to mention some examples of significant correlations (the highest) should be correlated MOTIMA CONFICO vs. (0,275), vs. MOTIMA INTEMACO (0,307) and the rest of the variables are presented in the order of 0,11 to 0,22 their respective correlations between the variables involved in this study. In applying the extraction method of principal components in factor analysis with varimax rotation, the following results were obtained (Table 7).

Table 7 shows that the first component may explain the phenomenon in a 35.09%. Thus Eigenvalues for each component are in the "Total" column and the next column shows the percentage of variance explained by the extraction method, however to apply the rotation of the axis look like the percentage of particular explanation varies, but the accumulated remains are the same, this is because at the time of the rotation, component variables change, but the goal remains the same, which is to minimize the distances between each group losing as little information as possible while increasing the ratio of the remaining variables in each factor.

Table 7. Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1.755	35.091	35.091	1.755	35.091	35.091
2	0.946	18.918	54.010			
3	0.864	17.283	71.292			
4	0.784	15.682	86.974			
5	0.651	13.026	100.000			

Extraction Method: Principal Component Analysis.

Based on the theory behind this work, we can say that with the technique of factor analysis, we pass from six observed variables to a "dummy variable" which explains 35.091% of the total variation, as can be seen also in the graph of sedimentation.

Graphic 1. Component number and eigenvalues

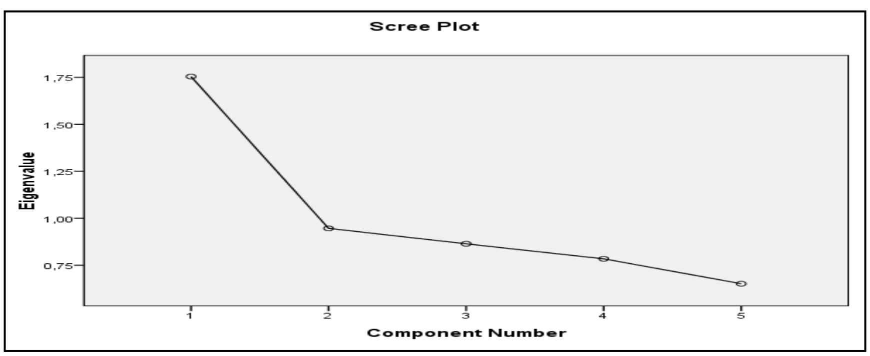


Table 8. Matrix of component number and variance

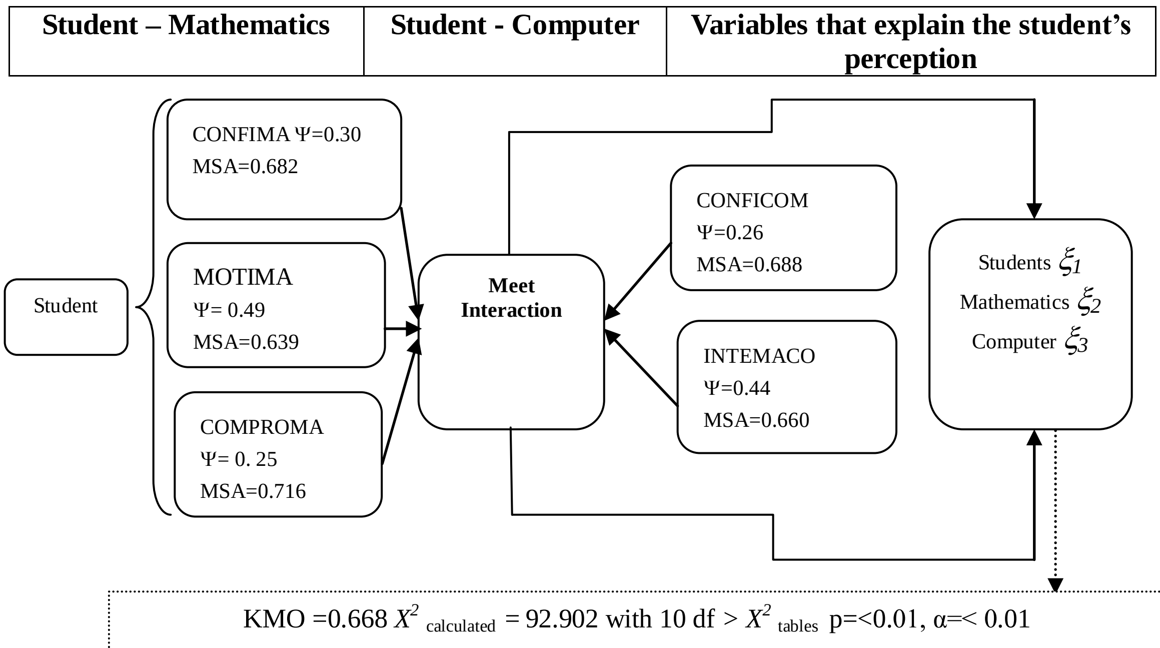
Factors	Component 1	Communalities
CONFIMA	0.554	0.307
MOTIMA	0.701	0.491
COMPROMA	0.502	0.252
CONFICOM	0.515	0.265
INTEMACO	0.663	0.440
Eigenvalue and total of variance		1.755 =35.091

Source: self made

The above table contains the projections of each of the variables on each of the factors found by the method of principal components, these projections are called *saturation.* By adding the square of each *saturation* for each component "factor" is obtained in this case their Eigenvalue is 1.755 and represent the 35.091% of variance. This means that five variables are sufficiently explained with the factor that added: CONFIMA, MOTIMA, COMPROMA, CONFICOM and INTEMACO.

Finally, the theoretical model is validated and showing the following correlated indicators.

Figure 2. Theoretical Path Model validated



7. Conclusion

Returning to the objective set at the beginning, this research shows evidence that the student's attitude in this area of knowledge is favored by the confidence, motivation and interaction between mathematics and computer, when each of these factors are present, the attitude of students towards the learning of mathematics and computer are enhanced. Motivation --component with most significance 0.701-- play an important role in the student's perception to improve their learning in this discipline and has significant implications for the planning of teaching and learning activities.

Based on the results described in Table 4, it shows that the variable COMPROMA (20.62%) has a greater dispersion compared with the rest of the variables that show similar behavior. Furthermore, the KMO statistic had a value of 0.668 (table 5) which is close to one, indicating that the data were adequate to perform a factor analysis and contrast of Bartlett test of sphericity (X^2= 92.928 $_{\text{calculated}}$ with 10 df> X^2 $_{\text{table}}$) with p-value 0.000 generated significant evidence to reject the null hypothesis (Ho) which stated that the initial variables were not correlated, having proven that they show correlation, therefore we can make a factor analysis which allowed to answer the research question. Also, Table 6 shows that the determinant was high (0.732) indicating a low degree of inter-correlation between the variables (<0.5). However, it should be noted that the variables show a positive correlation, but these results should be taken with precaution. For example, significant correlations (the highest) were taken from CONFICO vs MOTIMA correlated (0.275) CONFICO vs INTEMACO (0.307) and the rest of the variables are presented in order from 0.11 to 0.22 with their respective correlations between the variables involved in this study.

And with respect to the variance obtained in Table 7 shows that the first component CONFIMA, may explain the phenomenon studied with a 34.8%. Thus, we can say that although the results were not optimal in terms of correlation values is concerned; the variables involved in the model proposed by Galbraith and Hines (1998) do make a difference when students learn mathematics mediated by computer.

This evidence favors the understanding of learning environments in mathematics and how they are favored by the introduction of computers and technology.

Finally, with this research, we try to demonstrate the implications of confidence, motivation, engagement and interaction with the technology in the teaching-learning process, and in the same way as did Galbraith-Haines, we concluded that our Alternative hypothesis *H1*: The latent variables Mathematics confidence, Mathematics motivation, Computer confidence, Computer motivation, Computer-Mathematics interaction and Mathematics engagement, help to understand the student's attitude toward mathematics and technology.

8. Recommendation

Remember that the purpose of this study was focused on seeking to measure the interaction between students, mathematics and computer use. In order to try to understand how these elements interact with each other and to know if the construct proposed by Galbraith and Hines is capable of measuring in Latin America and more specifically in higher education institutions in Mexico. According to our findings, the interaction between student and computer for learning mathematics is positive. However, in future research, it is important to consider educational technology in the teaching-learning process of mathematics. As the computer and educational software industry advances and is constantly innovating, these advancements are very likely to make important contributions to the processes of teaching and learning.

Further research is recommended to consider situations such as spatial infrastructure to carry out the learning experience, cultural background, nationalities of the students, their socio-economic level, past experiences with mathematics and conducting a qualitative study of the interaction between students, math and computers.

Nowadays, the latest topic is the importance of understanding the interaction between the student, mathematics and computers, as computers play an active and leading role in education every day. The development of new techniques in its use is vital to all involved in the educational process, directly or indirectly.

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Appendix

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

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

I like to stick at a mathematics problem until I get it out					
The defy of understanding mathematics does not appeal to me					
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
I prefer to work with symbols (algebra) than with pictures (diagrams and graphs)					
I prefer to work on my own than in a group					
I find working through examples less effective than memorizing given material					
I find it helpful to test understanding by attempting exercises and Problems					
When studying mathematics I try to link new ideas or knowledge I already have					
When learning new mathematical material I make notes to help me understand and remember					
I like to revise topics all at once rather than space out my study					
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
As a male/female (cross out which does not apply) I feel disadvantage in having to use computers					
I have a lot of self-confidence in using computers					
I feel more confident of my answers with a computer to help me					
If a computer program I am using goes wrong, I panic					
I feel nervous when I have to learn new procedures on a computer					
I am confident that I can master any computer procedure that is needed for my course					
I do not trust myself to get the right answer using a computer					
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
Computers help me to learn better by providing many examples to work through					
I find it difficult to transfer understanding from a computer screen to my head					
By looking after messy calculations, computers make it easier to learn essential ideas					
When I read a computer screen, I tend to gloss over the details of the mathematics					
I find it helpful to make notes in addition to copying material from the screen, or obtaining a printout					
I rarely review the material soon after a computer session is finished					
Following keyboard instructions takes my attention away from the mathematics					
Computers help me to link knowledge e.g. the shapes of graphs and their equations					