ISSN 0798 1015

REVISTA ESPACIOS

EDUCACIÓN • EDUCAÇÃO • EDUCATION

Vol. 41 (Issue 11) Year 2020. Page 19

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A model of structural equations of possible factors that cause poor academic performance in mathematics

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Received: 15/12/2019 • Approved: 18/03/2020 • Published: 02/04/2020

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ABSTRACT:

This research examined through a model of structural equations, the possible factors of the Affective Domain that favor students under academic performance in Mathematics. The sample was 380 students between 4th and 7th grades of Basic Education from two public institutions. The instrument included sociodemographic, academic, pedagogical, and basic descriptors of the affective domain of mathematics. The results highlight that students' likings, attitudes and beliefs in mathematics, together with the activities that the teacher implements in the classroom, are decisive in the academic performance of the students.
Keywords: Mathematics, variable correlation, causal model, academic performance, affective domain.

RESUMEN:

En esta investigación se examinó por medio de un modelo de ecuaciones estructurales, los posibles factores del Dominio Afectivo que propician en estudiantes bajo rendimiento académico en Matemáticas. La muestra fueron 380 estudiantes entre 4° y 7° de Educación Básica de dos instituciones públicas. El instrumento incluyó variables sociodemográficas, académicas, pedagógicas, y descriptores básicos del dominio afectivo hacia las Matemáticas. Los resultados destacan que el gusto, las actitudes y las creencias que tienen los estudiantes por las matemáticas, junto con las actividades que implementa el docente en el aula, son determinantes en el desempeño académico de los estudiantes.
Palabras clave: Matemáticas, variables correlacionadas, modelo causal, rendimiento académico, dominio afectivo.

1. Introduction

Today's society education requires a new teaching proposal, which considers the motivations, needs and expectations of students in their curriculum planning process. An education that responds to the needs of the new millennium characterized by constant change, by the trend towards globalization of economies and societies, in line with the quality of education that should be delivered in the various centers regardless of their public or private nature.

In this regard, and since the Education Sciences, a wide range of research has been led, some student-focused looking to identify learning difficulties (Font, 1994; Rico, 1995; Polo & Rodríguez, 2006; Juidías Barroso & Rodríguez Ortiz, 2007), while others have focused on teachers and some aspects associated with the teaching process that they perform, such as their pedagogical practices, teaching processes and their evaluative practices (Chevallard, 2001; Llinares, 2009, 2012, 2013; Godino, 2013); finally, a small number of them, have considered the regulations that control the educational process in Colombia and how efficient it could become in the pedagogical exercise inside of the institutions (Gómez, 2010; Suárez, Ballen, & Amaya, 2011; Guacaneme, Obando, Garzón, & Villa-Ochoa, 2013).

Most of the research that has been developed around the teaching processes of Mathematics, has come to the same conclusion: the pedagogical practice performed by the math teacher is strongly focused on the management of procedures that end up triggering the memorization of various solution algorithms that are far from the development of the mathematical processes that are expected to reach students in their academic training process, as in the particular case of Colombia (Gómez, 2010).

Authors such as Rodríguez (2012) and Müller, Engler, & Vrancken (2012) claim that failure to learn mathematics still prevails, indicating that those who study this subject continue to be unmotivated to learn it. In the face of this, Veiga (2012) invites to continually review the performance not only of those who learn but also of those who teach.

The research carried out by Gonzaléz de Hernández (2013) and Paulino & Marmolejos (2013) insists that there are failures in the process of training teachers who teach this subject, which makes it possible to conclude that in many cases failures are not always the responsibility of the students. For this reason, a number of researches have been carried out in which various strategies are designed to support the improvement of learning in Mathematics, which have been based on failure in teacher training, demotivation and affection for Mathematics (Parra, 2013; Camacho, 2013).

It could then be said that teaching is highly fraught with feelings, aroused and directed not only at the conceptual appropriation of knowledge, but also to the formation in values and ideals. The above has made that in the last five decades the focus centers on the influence that affective reactions have on the process of both teaching by the teacher as well as student-oriented learning.

Martínez (2011) reports the impact of beliefs and attitudes on learning Mathematics, noting that students lose interest and liking for math by observing that their foundations are poor in solving the challenges proposed and then prevents them from overcoming a good number of obstacles that usually arise in their training process. Especially when it is not possible for you to use it as a tool to identify, describe, explain, contrast, evaluate, conjecture and predict facts and situations at different times and contexts. Other affective factors are also present in the success, or failure, of teachers and their students, in relation to the Mathematics that is taught, learned or evaluated.

That is why, on this reference basis, this document was developed, the objective was to analyze the possible relationship between the basic descriptors of affective domain and academic performance in Mathematics in the opinion of a group of students from Basic education of a public school.

1.1. Affective Domain Basic Descriptors

By reviewing the literature it can be evidenced that there is a whole range of factors that shape the affective domain that begins with conceptions, to move towards ideas, feelings, appreciations, preferences, values, attributions; others linked to both personal and social development that end up being evident in motivations, beliefs, emotions and attitudes. All of them present an unclear border and no specific division from each other, so it is difficult to try independent treatments of some of them. However, for the purposes of this research, beliefs, attitudes and emotions are identified as the three basic descriptors of affective domain.

As for beliefs, Martínez (2011) considers that they constitute guiding principles that are part of the knowledge acquired by subjects on the basis of their life experiences. They have an intersubjective character and represent constructs that, implicitly, are present when acting before the object or subject that motivates them.

In relation to emotions, this same author, based on what is reported by Gómez Chacón (2000) and Calhoun & Salomón (1989), concretes that they are a complex functional state that involves both physiological and psychological processes, being the first of organic and the latter correspond to mental activities and, therefore, of cognitive scope. Goleman (1996) evidentiates that, apart from the above, there are feelings associated with: (a) thoughts, (b) psychological and biological states, and (c) trends of acting, among others.

As for attitudes, Martínez (2011) states that they assess mental or evaluative reactions manifested through pleasure or displeasure towards any object, subject or situation. This forces us to think of various edges, as well as components: cognitive, affective, conative and behavioral, without excluding axiological (Gallego Badillo, 2000).

1.2. Importance of affection in learning Mathematics

In the math learning process, students are exposed to a diverse number of experiences that produce reactions that affect the formation of their beliefs about mathematics and about themselves in relation to that subject (Gómez Chacón, 2000). In this regard, Martínez (2008) adds that such beliefs can affect their behaviors and actions in learning situations and their ability to learn the mathematical concepts. These, in turn, can provoke emotional reactions that could be automated and become attitudes that contribute to the formation and maintenance of those beliefs. Such a situation is one of the approaches that make it possible to assert that the learning of Mathematics is directly related to affection, being able to establish connections, relationships or functional and non-functional explanations between the Committed factors that underlie not only those who learn but also those who teach or plan, without excluding the other subjects or sociocultural groups that may impact these processes: the classmates, the teachers of whom students previously received class, parents and society in general (Martínez, 2014).

In this order of ideas, the connection between mathematics learned and affection for that subject is based on factors such as emotions, beliefs and attitudes towards Mathematics. This connection has been neglected when considering the academic failure of students, the failure of teaching practices or the same educational system that seeks to respond to the manifest needs of the social, economic and political environments; then in the end it could highlight the widespread presence of moments of dissatisfaction, frustration, anger, disgust, detachment, uncertainty, fear, aversion, discouragement, endurance or concern that limits the learning of Mathematics.

Because learning also depends on the context and others, then what the actors involved in the class think, do or say outline, impact and are impacted by what is happening there. Although it is advisable to treat cognitive, social and affective in an integral way, the discussion in this document skews towards the affective by playing a leading role in: (a) facilitation or inhibition of learning Mathematics; and (b) success, or failure, both professional and personal of subjects, which, according to Goleman (1996), has greater dependence on the emotional than in the cognitive.

2. Methodology

The characteristics of the developed methodology are described below.

2.1. Focus and design

The research carried out is part of the mixed approach in which two stages are developed, starting with the quantitative phase in which a series of correlations are determined that allow to arrive at the construction of a causal model based on the technique called Structural Equations and that is articulated in a way consistent with some research work that precedes this process; subsequently progress to the qualitative phase in which a series of interviews are intended to validate the effectiveness of the proposed model.

The design of the research conforms to the characteristics of the non-experimental cross-section in which three phases distributed sequentially are distinguished, starting from a descriptive report to advance the modeling of relationships and correlations, to close with the analysis of the relevance of the model built.

2.2. Population and sample

The population was made up of all students enrolled by 2019 in two public educational institutions located in the city of San José de Cúcuta. The two educational institutions offer education to students from the First grade of Primary Basic Education to the Eleven degree in Vocational Middle Education. The two institutions are working on two separate courses, one in the morning and one in the afternoon. The institutions serve students from socioeconomic strata between 1 and 3, with a wide range of options in terms of the composition of the home, parental economic activities, access to technological resources that support their academic performance, among other important aspects.

For the selection of the sample, non-probabilistic sampling was used under the intentional sampling technique, meeting as with the following selection criteria: a) actively participating throughout the year 2019 at one of the selected educational institutions; b) Being a student between grades fourth and seventh; c) Parental consent. Based on the fulfillment of these selection criteria, a sample size of 380 students was consolidated.

2.3. Instrument for data collection

The survey was used as a data collection technique in this investigation. The instrument consisted of two sections distributed as follows: in the first section some descriptives were incorporated both of the students (age, grade, gender, liking for Mathematics and notes obtained in the last academic period) and of the institution (type of institution and geographic location); later in the second section 57, single-response multiple-selection items were incorporated, with a Likert scale with five levels (two negative perception, two positive perception and one intermediate option).

These items analyzed the various aspects associated with the basic affective domain descriptors distributed as follows: a) Beliefs with 13 items; b) Attitude with 14 items; c) Emotions with 10 items; d) Creativity with 3 items; and a complementary category corresponding to the evaluative practice that is promoted in the classroom by teachers, with 7 items, was included.

The instrument was initially applied to a group of 40 students from another institution with characteristics similar to those of the sample institutions. From this pilot application is derived the reliability report which it released at the general level of the whole instrument, a value of 0.813 in the Alpha coefficient of Cronbach which according to Oviedo & Arias (2005) is admissible as valid in the instrument. Reliability values for each of the constructs are shown in Table 1.

Table 1
Reliability index - Cronbach's Alpha
using the two-halde method

Construct or Escale	**Reliability Value**
Beliefs	0.743
Attitudes	0.835
Emotions	0.872
Creativity	0.689
Evaluative Practice	0.854
Total	0.813

2.4. Data collection process

Following the design and validation of the instrument, the approach to the educational institutions in which the research would be advanced, for which the director of each school was contacted, the project was presented, the scopes and objectives pursued. Subsequently, the parents of each student were asked to have informed consent that their children were informants of the investigation, for which they were given a document explaining what was intended to be done together with the authorization. This process was carried out over two weeks and thus the group of informants for the investigation was completed.

2.5. Data processing and analysis

SPSS software was used to contrast hypotheses and determine correlations between each of the mathematical processes, sociodemographic variables and academic performance of students in the area of Mathematics. For the degree of association (correlation coefficient) between the variables under study, the Spearman Rho coefficient was applied which is used to determine the independence or dependence of two random variables (Pérez-Tejada, 1998). Spearman's Rho correlation coefficient is the coefficient used when the variables are ordinal and/or the presumption of normality is not met.

This coefficient is very useful when the number of associated subject pairs is less than 30, but it is also useful with large sample sizes (as is our case). Its value ranges in the range of -1 to 1. The value of zero indicates that there is no correlation between the analyzed variables, while a value of -1 implies a perfect inverse correlation between the variables and the value of 1 is full evidence value direct correlation between them (Aguayo & Lora, 2007).

3. Results

The description of the characteristics of the sample begins with the determination of a slight predominance of the male gender in 51% of the members of the sample. The average age was 10.7 years with a minimum of 8 years and a maximum of 13 years. With respect to the total sample size, its distribution by degrees was 20% in Fourth, the 28% in Fifth, 30% in Sixth and 22% the in Seventh. 68% of the students say they like math and the average rating obtained in the last period was 6.8 on a scale of 0 to 10.

With regard to the basic descriptors of the Affective Domain, Beliefs around Mathematics and Attitudes 65% of favorable perception regarding their development in the classroom, recognizing that the teaching activity promoted in the classroom influences significantly in the perception of the subject, which can be seen in the category of the Teaching Activity where the various characteristic aspects of this work are contemplated.

Since there are phenomena with many variables to consider, following multiple causes are often measured with a certain level of error, adequate multivariate methods are required to identify the origin of such variability. The reason is that modeling is used by Structural Equations since it is a modeling technique that combines Multiple Regression, Combinatory Factorial Analysis and Trail Analysis, using all of them in order to examine several relationships simultaneously.

Among the advantages that can be highlighted from the structural equations models, it is emphasized that: a) it allows to work with latent variables or constructs that are measured through indicators; b) incorporates multiple endogenous and exogenous variables; (c) allows to evaluate the effects of latent variables with each other, without contamination resulting from the measurement error; and finally, d) the researcher introduces theoretical knowledge into the specification of the model.

Within the process of modeling with structural equations, the measurement model must first be established, in which the relationship between the latent variables and their respective indicators as described in Gil, Blanco, & Guerrero (2005) is identified. These relationships are shown in Table 2.

Table 2
Relationships Defined in the Measurement Model

Latent Variable	**Indicators**
Beliefs	About Mathematics and its teaching and learning process
	About Yourself as a Math Apprentice
	On teaching mathematics
Attitudes	I was doing the math
	Mathematical attitudes
Emotions	Automatics
	Consequence of physiological activations
Creativity	I'm creative

	Mathematics promotes and requires creativity
Evaluative Practice	Content development
	Type of evaluation that develops
	Frequency of evaluation

Table 3 shows the value obtained from Spearman Rho´s among the variables that were significantly correlated, emphasizing that as variables directly influencing the Academic Performance of Mathematics students are the Beliefs and Attitudes. The Evaluative practice turned out to be directly related to the Teaching Activity, but not to the Academic Performance, while the descriptors of the affective domain together with the teaching activity turned out to be directly related to the Liking for Mathematics, and the grade (Course) that the student was taking, turned out to be correlated with Beliefs, Mathematical Communication and Teaching Activity.

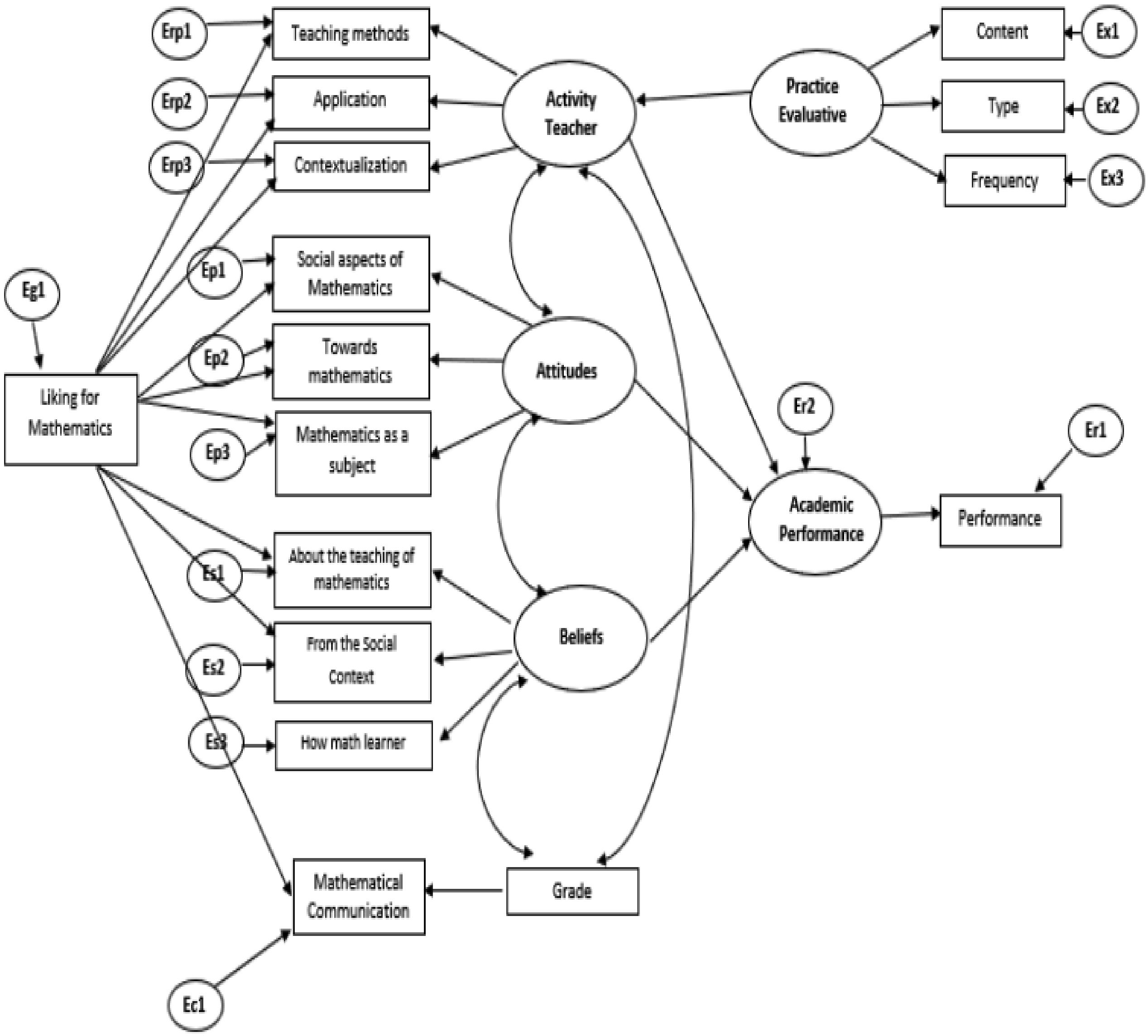
Table 3
Summary of significant correlations between the variables analyzed

Latent Variables	**Spearman Rho´s**
Teaching activity – Attitudes	0.711
Teaching activity – Evaluative practice	0.756
Teaching activity – Academic performance	0.729
Attitudes – Beliefs	0.825
Attitudes – Academic performance	0.803
Beliefs – Grade	0.784
Beliefs – Academic performance	0.701
Grade – Mathematical Communication	0.846
Grade – Teaching activity	0.755
Liking for Mathematics – Teaching activity	0.698
Liking for Mathematics – Attitudes	0.743
Liking for Mathematics – Beliefs	0.788
Liking for Mathematics – Mathematical Communication	0.802

After the verification of the particular correlations, progress is made in the construction of the proposed model which can be visualized in Figure 1 by using the Analysis of Moment Structures - AMOS which is an application is offered by SPSS. The next step is the estimation of parameters for which the traditional method of Maximum Verisibility is discarded because the assumption of multivariate normality between the variables involved in the proposed model is not met.

Due to non-compliance with the assumption of normality of variables, the Asymptotic Free Distribution Criterion – ADF was selected as an alternative method since its application is possible when the assumption of normality is violated. Once you can estimate the measurement model, you will evaluate the form in each indicator with each latent variable, and then estimate the parameters of the structural model in which each of the proposed causal relationships are studied.

Figure 1
Structural Equation Model Proposal



4. Conclusions

From the results obtained in this research, a history is being generated that allows to corroborate the relationships that have been mentioned in various works (Gómez Chacón, 2000 and Martínez, 2008), but that had not been quantified under the structural equation technique in the regional context of the Department of Norte de Santander.

There is research in which the student's grade was found to be a significant or influential factor with the academic performance of students. It was determined that liking for mathematics is directly affected by or related to Beliefs, Attitudes and Emotions towards mathematics; but Creativity was determined to be slightly related to Academic Performance. Meanwhile, the three basic descriptors of the Affective Domain in this sample, allow us to ratify that in the classroom work we should not ignore the importance and effects that emotions and affection can have on the academic performance of the student.

It was possible to verify that there are latent variables that are strongly linked to each other as is the case of the Teaching Activity with the Evaluative Practice which is obvious since the evaluation process is part of the components corresponding to the school curriculum in any educational scenario.

With regard to latent variables that report direct correlation with Academic Performance, it was identified that Teaching Activity, Attitudes and Beliefs are significantly related.

Within the latent Evaluative Practice variable, it could be shown that the indicators of Evaluation Context, Evaluation Type and Frequency of Evaluation were significantly related to the pedagogical practice that the teacher promotes in the classroom. This confirms that the evaluation in Mathematics is still a topic to be discovered and investigate where it is open to proposals and nothing is an absolute truth.

Finally, an important aspect of structural equation models is the fact that within the measurement model it is possible to quantify the level of impact of the measurement error associated with each variable and indicator while quantifying the relationships between variables. Then the next step is to determine the magnitude of the loads to advance to the validation phase of the model within a qualitative research approach.

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