DOI: 10.21276/sjpms

Scholars Journal of Physics, Mathematics and Statistics **ISSN 2393-8056 (Print)**
Sch. J. Phys. Math. Stat. 2017; 4(2):57-78 **ISSN 2393-8064 (Online)**

Measurement of Beliefs, Attitudes, Emotions and Valuation in Training About the Teaching of Mathematics

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Abstract: This investigation focuses on beliefs, attitudes, emotions and valuation in training about mathematics of 200 students from Universidad Privada Boliviana (UPB) in Bolivia. An instrument was designed to measure these aspects by verifying the structure proposed by Caballero and Blanco[1] and by Caballero, Guerrero and Blanco[2], using confirmatory factor analysis (CFA), consisting of 6 factors, 19 dimensions and 75 items. The scores obtained in each factor and dimension were analyzed, showing that the students from UPB have beliefs, attitudes, emotions and valuations about their training in mathematics that are positive and of a moderate level, and are increasing as the student goes into higher mathematics subjects level. A structural equation modeling (SEM) was performed to observe the relationships among the 6 factors studied. The most remarkable finding was that the factor of the role of the teacher of mathematics in teaching and the factor of beliefs that the student has as an apprentice of mathematics are the most influential in his valuation of his training in this area. Subsequently, a much shorter measuring instrument was proposed, with 6 factors, 11 dimensions and 31 items, making an exploratory factorial analysis for the elimination of items and dimensions, due to the fact that a robust structure was not obtained through the CFA. Also, we obtained personal and academic profiles of the students of UPB that presents positive characteristics about mathematics. Finally, some implications were analyzed that help to improve the academic management of the UPB.
Keywords: Beliefs, attitudes and emotions towards mathematics, confirmatory factor analysis (CFA), exploratory factor analysis (EFA), structural equation modeling (SEM), assessment of mathematics training, affective domain in mathematics teaching

INTRODUCTION

When you think about the nature of mathematics and its use, everyone realizes that it is not only a university subject, but that it is of common interest in all spheres of society. Mathematics is like music, athletics, and science; a product of culture [3]. However, many university training centers have failed to devise a strategy, methodology, and content in their math subjects that fosters the application and motivational approach so that students are interested in their studies and can change their beliefs and attitudes toward math.

Since the 1970s several researchers have studied different aspects and with different approaches the influence of students' beliefs and attitudes on their performance in mathematics [4-10]. Numerous instruments have been designed for measurement, all with different dimensions [11-13]. These studies have eased the way for changes in mathematics programs and can be measured and compared.

With the help of these instruments, several studies have been carried out proposing different learning strategies to obtain positive attitudes towards mathematics by students [14]. The most representative studies are: analysis of how music can raise attitudes toward mathematics [15], cognitive-behavioral strategies to reduce anxiety and blocking problem solving [16], identification of students' typologies regarding attitude towards mathematical science [17], the relation between attitudes and reprobation in mathematics [18], the relation of the use of technology and performance in mathematics [19, 20], and the analysis of the relation between attitude of teachers and students about performance [21, 22].

There is very little research that has explored the analysis of the complex relationships that exist between different types of beliefs about mathematics (beliefs about the nature of mathematics, beliefs about oneself as an apprentice of mathematics, beliefs raised by context socio-family, etc.), different types of attitudes (cognitive, affective and behavioral), with a measure of performance or assessment in the training received [1, 2, 23-25].

In this research, we first try to verify the robustness of the dimensional structure proposed by Caballero and Blanco [1] and Caballero, Guerrero and Blanco [2] for the study of the affective domain towards mathematics, using confirmatory factor analysis (CFA). In addition, a structural equation modeling (SEM) will be performed to understand the complex relationships that may arise between beliefs, attitudes and valuation in mathematics training in the context of higher education. Then, the results of the scores obtained by a sample of university students about their beliefs, attitudes, emotions and valuation in training of mathematics through descriptive statistics will be analyzed and then a profile of the student will be elaborated that presents a positive affective domain, using the analysis of variance (ANOVA) and the test of multiple ranges of the least significant difference (LSD). All these analyzes can provide the information to detect some aspects about the teaching of mathematics that influence the university student (beliefs, attitudes and emotions) to achieve a good performance and a positive valuation of their training, and to propose some improvements so that undercase the university modifies or carries out programs in its academic management in order to positively change these beliefs and attitudes.

OBJECTIVES

Several objectives have been set out for this study:

1. Check the robustness of the factor structure proposed by Caballero and Blanco [1] and Caballero, Guerrero and Blanco [2], on the beliefs, attitudes and valuation of training towards mathematics, through confirmatory factor analysis (CFA), and obtains a valid instrument for measurement.
2. Propose a structural equation modeling (SEM) to establish the relationships between beliefs, attitudes and assessment of the training received in studies in relation to mathematics.
3. To construct a valid and reliable instrument to measure the attitudes, beliefs and valuation of training towards the mathematics of UPB students, if through the CFA it is verified that the classification of Caballero and Blanco [1] is not robust.
4. Make a diagnosis of the students evaluated at the UPB about their beliefs, attitudes and valuation of training towards mathematics, based on the analysis of the results obtained through the instrument developed, to detect failures that do not allow them learn properly.
5. Obtain a personal and academic profile of the UPB student who has beliefs, attitudes and valuation about training in mathematics that is positive.
6. On the basis of the diagnosis and analysis made, propose some guidelines for teaching mathematics to replace, maintain or reinforce positive beliefs and attitudes about mathematics, in order to remove obstacles that do not allow adequate learning.

LITERATURE REVIEW

Beliefs, attitudes, and emotions about mathematics

McLeod [7, 26] was one of the first researchers to note that emotional problems play an essential role in the teaching and learning of mathematics, and that some of them are strongly rooted in the subject and are not easily displaceable by instruction.

Gómez-Chacón [8] affirmed that it has been difficult to find a clear definition of the affective domain in the teaching of mathematics. Some researchers consider the attitude toward mathematics as a simple taste or dislike of mathematics, [27] while others extend the meaning to a more complex phenomenon that includes beliefs, emotions, attitudes, behavior, ability, values, and the usefulness of mathematics; i.e. a multidimensional perspective [28-30].

Beliefs are part of cognitive domain knowledge, composed of affective, evaluative and social elements, with strong stability. This knowledge refers to mathematics and its teaching and learning and is based on experience [8]. In this sense, beliefs are the set of perspectives that a person has about mathematics and their learning and propitiate or hamper the development of skills in this area of knowledge [31].

McLeod [7] differentiated 4 factors that are based on beliefs regarding the teaching of mathematics: 1) beliefs about the nature of mathematics and its teaching and learning, 2) beliefs about oneself as an apprentice of mathematics , 3) beliefs about the teaching of mathematics, and 4) beliefs aroused by the social context.

Gómez-Chacon [8] assumes the definition of Hart [29] who posits the attitude as an evaluative (i.e., positive or negative) predisposition that determines personal intentions and influences behavior. Attitudes in mathematics are made up of three components: cognitive, affective and behavioral, in which two categories can be distinguished [32]: 1) attitudes towards mathematics, referring to interest, satisfaction, curiosity and valuation towards mathematics, their teachers, their methods of teaching, etc. (affective component), and 2) mathematical attitudes (cognitive component), referring to the use of skills to perform mathematical work, such as objectivity, logic, mental effort, etc.

Emotional reactions to mathematics have been less studied. According to McLeod [33], the greatest difficulty is the lack of a theory to interpret the role of emotions in learning mathematics.

Emotions are rapid changes of feelings and strong intensity; organized responses beyond the boundary of psychological systems, including the physiological, cognitive, motivational, and experiential systems. They appear as a response to an internal or external event, with positive or negative meaning for the individual. The class of emotion-related ratings follows the occurrence of some cognitive perception or discrepancy in which the subject's experiences are infringed. Therefore, emotions are strong effective responses that are not only automatic or a consequence of physiological activities, but are the complex result of learning, social influence and interpretation [8].

Gómez-Chacón [8] indicates that affections can influence in several ways, fulfilling the function of 1) teacher-student relationship and learning system, 2) learning experience indicator, 3) impulse or resistance to activity mathematics, and 4) knowledge facilitator.

Some authors [23, 24] have proposed to establish the relationship between beliefs, attitudes and emotions towards mathematics and the value / utility of mathematics. However, only Caballero and Blanco [1] and Caballero, Guerrero and Blanco [2] have established the relationship between valuation in the training of mathematics and the affective domain. They concluded that the students who want to obtain the title of teacher in mathematics, due to their studies of teaching, have not changed their perception on mathematics, although they have produced a favorable change in the valuation granted to that discipline. The majority completed their expectations regarding the training received from didactics of mathematics, which provided them with other ways of approaching mathematical problems, and for that reason they felt trained with the training received to practice teaching in the area of mathematics at the level from elementary school.

Measuring instruments beliefs, attitudes and emotions about math

There are numerous instruments in the literature to measure beliefs, attitudes and emotions about mathematics, each with a different emphasis and involving different factors. A non-exhaustive but representative summary of these instruments is shown in Table 1.

Table 1: Instruments for measuring beliefs, attitudes and emotions about teaching mathematics

<table>
<tr><th>Author</th><th>Factors</th><th>Author</th><th>Factors</th></tr>
<tr><td rowspan="9">Fennema-Sherman [12], quoted in Kienfie et al. [34]</td><td>Confidence in learning math</td><td rowspan="4">Schackow [45], quoted in Sweeting [43]</td><td>Value</td></tr>
<tr><td>Mother's attitude</td><td>Pleasure</td></tr>
<tr><td>Father's attitude</td><td>Self-confidence</td></tr>
<tr><td>Attitude towards success in mathematics</td><td>Motivation</td></tr>
<tr><td>Attitude of the teacher</td><td rowspan="3">Canul [44]</td><td>Level of thinking towards mathematics</td></tr>
<tr><td>Mathematics (male domain)</td><td>Beliefs towards teaching mathematics</td></tr>
<tr><td>Usefulness of mathematics</td><td>Beliefs about learning math</td></tr>
<tr><td>Anxiety towards mathematics</td><td rowspan="4">Andrews [45], Mantecón et al. [46]</td><td>Role of the teacher</td></tr>
<tr><td>Motivational effect</td><td>Efficacy</td></tr>
<tr><td rowspan="4">McLeod [7]</td><td>Beliefs about mathematics and its teaching and learning</td><td>Relevance</td></tr>
<tr><td>Beliefs about oneself as an apprentice of mathematics</td><td>Memory learned and topic difficulty</td></tr>
<tr><td>Beliefs about teaching mathematics</td><td rowspan="2">Panaoura [47]</td><td>General self-representation of students</td></tr>
<tr><td>Beliefs aroused by the social</td><td>Self-representation about spatial skills</td></tr>
</table>

	context		
Callejo [32]	Attitudes towards mathematics	Rösken *et al.* [48]	Personal skills
	Mathematical attitudes		Effort
Vallejo y Escudero [35]	One factor		Quality of teachers
Fogarty [36]	Confidence in mathematics		Family stimulus
	Confidence in computers		The enjoyment of mathematics
	Attitudes towards the use of technology in learning		Difficulty in mathematics
Nurmi [37]	Self confidence		Self confidence
	Orientation to success	Muñoz y Mato [49]	Attitude of the teacher perceived by the student
	Defensive orientation		Affability and usefulness of mathematics in the future
Barkatsas [38]	Confidence in mathematics	Papageorgiou [50]	Beliefs (Self-confidence)
	Trust in technology		Beliefs (Value)
	Attitude to learn with technology		Attitudes
	Affective commitment		Modern teaching practices
	Behavioral Commitment	Cuervo [51]	One dimension
Klinger [39]	Beliefs of self-efficacy	Palacios *et al.* [52]	The perception of mathematical incompetence
	Affective attitude		The enjoyment of mathematics
	Behavioral attitudes		Perception of utility
	Cognitive Attitude		Mathematical self-concept
	Anxiety	López *et al.* [53]	Computer and mathematics interaction
Hidalgo *et al.* [40]	Attributions of causality		Attitudes toward learning with technology
	Taste for mathematics		Attitudes of the use of technology
	Mathematical self-concept		Math expertise with technology
	Mathematical attitudes and beliefs		Mathematics and technology
	Attitudes and beliefs about the teacher	Brandell y Nystron [54]	Revised Fennema-Sherman Scale
	Attitudes and beliefs about the family		
Chapman [41]	Pleasure	Arrébola y Lara [13]	Affective component
	Value		Cognitive component
	Coping		Behavioral component

Classification of Caballero and Blanco [1] and Caballero, Guerrero and Blanco [2]

Caballero and Blanco [1] and Caballero, Guerrero and Blanco [2], from the review of Gil's research [55], Gómez-Chacón [8], Callejo [32] and Amorin [56] developed an instrument to measure beliefs, attitudes, emotions and the value of the training received in mathematics, composed of 6 factors and 48 items (see Table 2). This classification constitutes the basis of the study that will be carried out in this article.

Table 2: Classification of Caballero and Blanco [1] and Caballero, Guerrero and Blanco [2]

N°	Factors	Dimensions	Notation
F1	Beliefs about the nature of mathematics and its teaching and learning	Vision of utility, applicability and importance of mathematics in all spheres of life	D1
		Perception of discipline as abstract, rote, mechanical knowledge	D2
		Student's view of how to learn mathematics	D3
F2	Beliefs about oneself as an apprentice of mathematics	Level of confidence and security in their skills, abilities and possibilities to successfully deal with the subject	D4
		Expectations of achievement related to pleasure and taste for learning mathematics and for influence when choosing different training paths,	D5

		with the desire to master the subject, with the recognition of others	
		Causal attribution of success or failure in mathematics (what motives attribute to success or failure - teacher, dedication, effort, luck)	D6
F3	Beliefs about the role of mathematics teachers	View of the personal characteristics and role of the teacher in the teaching-learning process	D7
		Methodology and didactic resources used by teachers	D8
		Teacher-student interaction	D9
F4	Beliefs aroused by the socio-family context	Interest of parents or siblings	D10
		Parent expectations	D11
		Interest of colleagues/Friends	D12
		Socioeconomic status, feeling of social competence, academic success, job success	D13
		Social stereotypes in mathematics	D14
F5	Emotional attitudes and reactions to mathematics	Degree of perseverance in the tasks	D15
		Level of satisfaction, interest, curiosity and safety in the matter	D16
		Level of anxiety (anxiety, fear), feeling of failure and frustration, blocking	D17
F6	Valuation of training received in studies in relation to mathematics	Satisfaction level in mathematics training	D18
		Student's view of the change in their attitudes and beliefs toward mathematics due to the studies	D19

Source: Caballero and Blanco [1], Caballero, Guerrero and Blanco [2]

The reliability of the instrument, measured by Cronbach's alpha was 0.617, which is considered low value to reflect the internal consistency.

Relationship between beliefs, attitudes, emotions towards mathematics and valuation in training

Gómez-Chacon [57], cited in Maroto [58], stated that the relationship between the emotions toward the mathematics is cyclical: the student's experience of learning mathematics provokes different reactions and influences the formation of his or her beliefs. Then, the student's beliefs mark his behavior in learning situations and in his ability to learn. When learning math, the student receives stimuli associated with mathematics (problems, teacher performances, social messages, etc.). Before then he reacts positively or negatively conditioned by his beliefs about himself and mathematics. By repeating the same kind of affective reactions (satisfaction or frustration) they become automated and consolidated into attitudes. These attitudes and emotions influence the beliefs and collaborate in their formation.

There is no empirical study in the literature that has tested these relationships, except for the study by Gamboa and Moreira-Mora [25]. Using a model of covariance structures, we concluded that there is evidence of a relationship between cognitive, affective and behavioral components with the attitude toward discipline. The didactic tendencies of the teachers and the teacher's perception presented evidence of a direct relation with the beliefs towards the mathematics and an indirect relation with the attitudes towards the matter. However, it was the student's self-image in the discipline that presented the greatest relationship. Therefore, in this article we want to make an attempt to elucidate these relations, through a structures equation modeling analysis (SEM).

EMPIRICAL STUDY RESULTS

Sample characterization

A research on the beliefs and attitudes about mathematics at the Universidad Privada Boliviana (UPB) was carried out, with a sample of 200 undergraduate students from both La Paz and Cochabamba undercase Campuses during the I-2014 semester. The characteristics of the sample are observed in Table 3. It was verified that the sample data was close to the population pattern of the students of UPB in both Campuses and to the academic pattern.

Table 3: Characteristics of the sample students

Characteristics	Modalities [%]			
Gender	Male	51	Female	49
Age	20 or less	90	More than 20	10
Campus	Cochabamba	26	La Paz	74
Faculty	Engineering	22	Business	78
Semester	First	68	Other	32

Scholarship	Without	70	With	30
Repeater	Yes	25	No	75
Favourite subject	Mathematics	36	Other	64

Instrument design

The instrument for measuring beliefs, attitudes and valuation in mathematical training was designed taking into account the classification of Caballero and Blanco [1] to establish the dimensions. This classification was chosen because it is the most exhaustive one found in the literature. To obtain a sample of representative items to cover the domain of each dimension, several instruments were reviewed in the literature, choosing 75 items, as shown in Table 4, since the 48-item tool developed by Caballero, Guerrero and Blanco [2] did not seem to possess a representative sample of items.

Table 4: Items and authors of the instrument

Item number	Author	Item number	Author
70	Aiken [11]	3-4,16,64,68	Klinger [39]
12-14, 54	Andrews [45], Mantecón *et al.* [46]	43	López *et al.* [53]
5,18,39	Arrébola & Lara [13]	31, 35	Muñoz y Mato [49]
17,37	Barkatsas [38]	58	Nurmi [37]
46,55	Brandell & Nystron [54]	59	Palacios *et al.* [52]
71-75	Caballero & Blanco [1]	36	Panaoura [47]
9	Cuervo [51]	22	Papageorgiou [50]
57,65,69	Fennema-Sherman [12]	32,44,23	Rösken *et al.* [48]
1-2,6-8,10-11,15,19-21,24-30,33,38,40-42,45,47-53,56,61-63,66-67	Gil *et al.* [59]	60	Vallejo & Escudero [35]
33,43	Hidalgo *et al.* [40]	23	Schackow [45]

The detail of the dimensions of each group of beliefs, attitudes and valuation in mathematics training and the items that comprise it is found in the Appendix. The format of the questionnaire was designed with a 7-point Likert scale ranging from 1 = "Strongly Disagree" to 7 = "Strongly Agree".

Verification of the dimensions of beliefs, attitudes, emotions and valuation in training about mathematics

A confirmatory factorial analysis (CFA), using the AMOS program 6, was used to verify if the structure given by Caballero and Blanco [1] and Caballero, Guerrero and Blanco [2] about beliefs, attitudes about mathematics and valuation in training is robust. Table 5 shows the items that were eliminated because they presented non-significant estimated values of regression in the t test lower than a level $p < 0.05$.

Table 5: Deleted items in the CFA

Factor	Dimension	Ítem
F1	D1	P2
	D2	P7, P8
F2	D6	P24
F3	D7	P32
F4	D12	P47
	D14	P54, P55
F5	D16	P63
F6	-	-

Table 6 shows the goodness of fit indices for each analysis.

Table 6: Adjustment indices for the CFA of the instrument

Group	Index	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
Chi square	χ^2	61.616	189.278	79.993	101.997	231.488	4.377
Comparative fit indices	NFI	0.918	0.693	0.914	0.831	0.776	0.987
	TLI	0.960	0.674	0.941	0.892	0.795	0.997

	CFI	0.970	0.748	0.956	0.918	0.833	0.999
	IFI	0.971	0.755	0.956	0.921	0.836	0.999
Indices of proportion of variance	GFI	0.948	0.859	0.932	0.930	0.839	0.991
	AGFI	0.916	0.785	0.891	0.893	0.772	0.968
Parsimony degree índices	AIC	111.616	243.278	129.993	165.997	293.488	26.377
	CAIC	219.074	359.332	237.451	303.543	426.736	73.658
Indices based on residuals	RMR	0.132	0.260	0.102	0.188	0.316	0.044
	RMSEA	0.050	0.117	0.069	0.061	0.103	0.022

It can be observed that the Chi-square test indicates that there is a good fit of the model with respect to the independent model (where no relation is significant). Comparative fit indices and indices proportion of variance are generally greater than 0.9 as suggested by Uriel and Aldás [60] so that there is a good fit, except for factors 2 and 5. The parsimony degree indexes are relatively low indicating that the factorial models are simple. Finally, the indexes based on residues are less than 0.1, except for factors 2 and 5.

It can be concluded that in general the structure of Caballero and Blanco [1] and Caballero, Guerrero and Blanco [2] is robust for factors 1, 3, 4 and 6 but for factors 2 and 5 it is necessary to obtain another dimensional structure.

SEM model of relationships between beliefs, attitudes and valuation in training about mathematics

An analysis of the direct, indirect and total effects of the relationships of the different factors of beliefs, attitudes and valuation in training about mathematics was performed through a structural equation modeling (SEM). The resulting model can give clues as to the cognitive mechanism by which students form their beliefs and attitudes toward mathematics and how they influence the valuation of the training received at UPB.

Figure 1 shows the initial modeling, showing only the structural component.

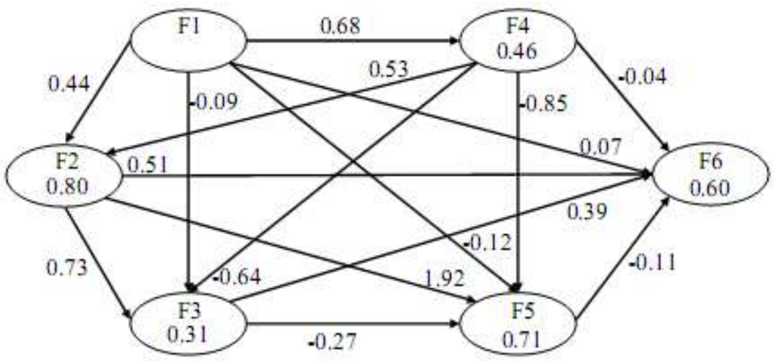

Fig-1: Structural equation modeling of beliefs, attitudes and valuation in training of mathematics

Several items were found to be not significant in each dimension. Also, several routes between factors were also not significant. This was tested at the p <0.05 level. The re-specified model is shown in Figure 2.

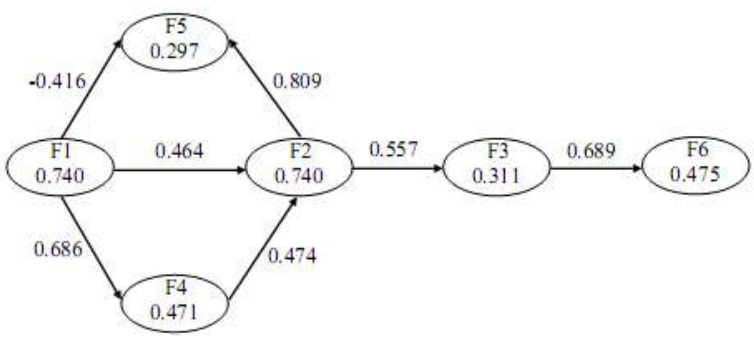

Fig-2: Reformed SEM model between beliefs, attitudes and valuation in training about mathematics

Table 7 shows the values of the direct, indirect and total paths of the model.

Table 7: Direct, indirect and total model paths

Factors	Path	F1	F4	F2	F3
F4	Direct	0.686			
	Indirect				
	Total	0.686			
F2	Direct	0.464	0.474		
	Indirect	0.325			
	Total	0.789	0.474		
F3	Direct			0.557	
	Indirect	0.440	0.264		
	Total	0.440	0.264	0.557	
F5	Direct	-0.416		0.809	
	Indirect	0.638	0.383		
	Total	0.222	0.383	0.809	
F6	Direct				0.689
	Indirect	0.303	0.182	0.384	
	Total	0.303	0.182	0.384	0.689

Observing the multiple square correlation of factor F6, we can conclude that there is an explanatory power of 47.5%, that is, that the antecedents of factor F6 can only explain in that percentage the valuation in training about the mathematics of students at UPB.

The path analysis is as follows:

- Factor 3 (beliefs about the teacher's role in teaching mathematics) is the only one that has a direct effect on factor 6 (value of mathematics training) and is the most significant (0.689).
- Factor 2 (beliefs as an apprentice of mathematics) is next in influence with an indirect effect of 0.384, through factor F3.
- Factor 1 (beliefs about the nature of mathematics) is the third factor in influencing the F6 factor indirectly with a value of 0.303, through F2, F4 and F3.
- Factor 4 (family beliefs about mathematics) is the last in influence, with an indirect effect of 0.182, through F2 and F3.
- Factor 5 (attitudes and emotions towards mathematics) has no significant effect on the valuation of the training received). These attitudes are formed by F1, F2 and F4, with F2 (beliefs as an apprentice of mathematics) contributing the most.

The modeling result shows that beliefs of a student about the nature of mathematics (F1) have a positive effect on their family beliefs (F4) and both in turn influence their beliefs as an apprentice mathematician (F2). The student's beliefs as an apprentice (F2) influence his beliefs about the role of the teacher in teaching mathematics (F3). In turn, these two beliefs influence his valuation in training about mathematics (F6). On the other hand, beliefs about the nature of mathematics (F1) have a negative influence on the attitudes and emotions towards mathematics (F5). However, beliefs as an apprentice in mathematics influence positively. Thus, we verify the cyclical nature of the relationships between beliefs, attitudes and emotions towards mathematics that Gómez-Chacón proposed [57].

Table 8 shows the goodness of fit indices of the model about the perceived formation in mathematics of UPB students.

Table 8: Model goodness-of-fit indices

Group	Index	Independent model	Analyzed model
Goodness of fit	Chi squared	7678.367	4285.632
	d.f.	2080	2010
	Sig.	0.000	0.000
	NFI	0.000	0.442

Comparative fit indices	IFI	0.000	0.599
	CFI	0.000	0.594
Indices of proportion of variance	GFI	0.235	0.579
	AGFI	0.211	0.550
Indices based on residuals	RMR	0.532	0.317
	RMSEA	0.116	0.075

The Chi-square statistic contrasts the hypothesis of perfect fit between the variance-covariance matrix observed and the reproduced one. Since the value obtained is 4285.632 (p = 0.000), the null hypothesis of perfect fit is rejected. That is, we cannot maintain the perfect fit hypothesis between the observed matrix and the one reproduced from the model analyzed.

The comparative fit indices and those of proportion of variance must be above 0.8 to indicate a good fit of the model. In this case none of them meets the requirement. The comparative adjustment indexes compare the value of the theoretical model that is evaluated with that of the independent model. This result suggests that the model is not so far removed from the similarity with the independent model, which is not desirable from a well-specified model. The indices of proportion of variance, establish the ratio between the variance-covariance matrix population and the sample. Both indices indicate that the model cannot explain an adequate proportion of population variance.

Residue-based indices should be less than 0.1. In this case the model meets the suitability of waste, with the exception of RMR. These indices are based on the average of the differences between the sample variances-covariances and the estimates derived from the model. This means that with the model an adequate similarity has been achieved between the sample-variance-covariance matrix and the population, which is desirable for a good specification of the model.

Proposal for the development of an instrument for the measurement of beliefs, attitudes and valuation in training towards mathematics for UPB

Although it was possible to verify by means of the CFA that the factorial structure to measure beliefs, attitudes and valuation in the training of mathematics is quite robust (with the exception of factors 2 and 5), a much shorter instrument is then proposed for continuous measurement at UPB. For this purpose we used the exploratory factorial analysis (EFA). The results are shown in Table 9.

Table 9: EFA results

Characteristics	EFA	Iteration 1	2	3	4	5	6	7
Deleted Items		7,8,9,13,15,16, 18,22,24,27,36 ,40,45,50,51,5 3,57,58,61,73	6,12,20,21,25 ,26,48,49,54, 62,72	37,56,6 5,71	64	46	47	23
Dimensions	20	15	12	12	12	12	12	12
KMO	0.813	0.806	0.806	0.809	0.803	0.804	0.806	0.802
Bartlett	7734.663 (d.f. 2701)	5163.858 (d.f 1431)	3686.680 (d.f. 903)	3286.114 (d.f. 741)	3136.583 (d.f. 703)	3081.914 (d.f. 666)	3041.166 (d.f. 630)	2924.949 (d.f. 595)
Cumulative variance extracted (%)	69.121	67.679	66.005	68.778	69.16	70.032	71.243	71.891
Non-redundant residuals greater than 0.05	349 (12%)	269 (18%)	215 (23%)	165 (22%)	155 (22%)	150 (22%)	137 (21%)	128 (21%)

Following a later analysis, it was considered appropriate to eliminate items 41, 55, 52 and 63, which form three factors that cannot be justified.

The resulting factor structure is shown in Table 10.

Table 10: Resultant factor structure

Item	1	2	3	4	5	6	7	8	Item	1	2	3	4	5	6	7	8
P1			0.798						P35	0.653							
P3			0.779						P38	0.742							
P4			0.849						P39	0.708							
P5			0.747						P42				0.665				
P10								0.769	P43				0.816				
P11								0.810	P44				0.788				
P14								0.693	P59					0.770			
P17						0.545			P60					0.761			
P19						-0.822			P66		0.748						
P28	0.727								P67		0.676						
P29	0.781								P68		0.810						
P30	0.821								P69		0.848						
P31	0.834								P70		0.841						
P32	0.786								P74							0.772	
P33	0.590								P75							0.729	
P34	0.737																

In this way, the structure and instrument for measurement would be simplified in the manner shown in Table 11.

Table 11: Simplified instrument through the EFA

Factor	Dimension	N°	Items
F1	D1	1	Mathematics is useful and necessary in all areas of life
		3	Good math training is a great advantage to access any type of work
		4	Mathematics make you think logically and systematically and teach you to be disciplined
		5	I will keep my notebooks or math texts because they will probably serve me
	D3	10	The best way to learn math is through individual study
		11	When teachers propose us group work there is usually a high level of interest and participation in class
		14	The time taken to understand why a solution works is a well-spent time
F2	D4 and D5	17	I have a mathematical mind
		19	The taste for mathematics influences when choosing a particular career in which they are not present
F3	D7	28	Mathematics teachers are always ready to help and clarify the doubts and difficulties that arise during the class
		29	Mathematics teachers are interested in my evolution and performance in the subject
		30	In mathematics class teachers value my effort and recognize my daily work in the subject
		31	The teacher encourages me to study more mathematics, advises me and teaches me to study
		32	The teacher is too good in mathematics, such that he cannot explain clearly
	D8	33	In mathematics class teachers use a variety of means and practical examples that allow me to relate mathematics to situations of my daily life
		34	The methods of mathematics teachers are often more boring than those of other subjects
		35	After each evaluation, the teacher comments on the progress made and the difficulties encountered
	D9	38	My relations with math teachers are satisfactory
		39	I get on well with my math teacher
F4	D10	42	My parents were pretty good at solving math problems
		43	Mathematics in my family is a subject that they consider very important
		44	The importance of math competence has been emphasized in my home
	D15	59	I can spend hours studying math and doing exercises
		60	I do not settle for giving a result, I want to be sure that I give it well and why I do it well

	D17	66	I am distressed and afraid when the teacher asks me by surprise to solve a problem
		67	When I get stuck or blocked in solving a problem I begin to feel insecure, desperate, nervous ...
		68	I'm afraid I'm not able to keep up with math class
		69	My mind goes blank and I cannot think clearly when I work in mathematics
		70	I am always under a terrible stress in a math class
	D19	74	My university studies have changed my perception of mathematics
		75	As a university student, I value the importance of mathematics more positively than before

The 6 factors were maintained, but dimensions D2, D6, D11-D14, D16 and D18 were eliminated. Thirty-one items were retained. The reliability measured by Cronbach's alpha was 0.804, showing that the instrument has a high internal consistency.

Results of student perception scores

The results found for the UPB students, by factor and dimension, are analyzed in Table 12.

Table 12: Results of the measurement by factor and dimension in the UPB

Factor	Dimension	Mean	SD	CV	Factor	Dimension	Mean	SD	CV
F1	D1	5.33	1.67	31.41	F4	D10	4.61	1.89	41.08
	D2	4.58	1.91	41.79		D11	5.38	1.66	30.93
	D3	4.44	1.78	40.15		D12	3.57	1.33	37.26
	Total	4.80	1.83	38.09		D13	5.17	1.50	29.05
F2	D4	4.57	1.69	36.87		D14	4.41	1.93	43.81
	D5	4.59	1.73	37.73		Total	4.68	1.83	39.21
	D6	4.72	1.86	39.50	F5	D15	4.68	1.70	36.33
	Total	4.62	1.76	38.07		D16	4.70	1.64	34.88
F3	D7	4.99	1.59	31.89		D17	4.38	1.80	4.10
	D8	4.55	1.72	37.88		Total	4.59	1.72	37.51
	D9	5.19	1.41	27.24	F6	D18	5.10	1.39	27.24
	Total	4.84	1.64	33.88		D19	5.25	1.53	29.13
						Total	5.16	1.45	28.06

For the F1 factor, UPB students have a high positive belief in the nature of mathematics and its teaching and learning, which is about partially agreed. The results of dimension 1 (D1) indicate that UPB students perceive that mathematics is useful, important and necessary, both for daily life and to develop in the professional field, and therefore, it is better to study and master it. The results of dimension 2 (D2) indicate a positive perception of the abstract of mathematics rather high (the scale was reversed so that the total factor makes sense since it was formulated in the negative sense). This presupposes that UPB students perceive that it is necessary to acquire the abstract logic of mathematics to solve problems of society. The results of dimension 3 (D3) indicate a quite elevated view of the learning mode of mathematics, with a value similar to dimension 2.

As for the F2 factor, UPB students are indifferent and partly in agreement about their safety and ability to deal efficiently with mathematics (D4), to take pleasure and pleasure in the formative pathways to master mathematics (D5) And attribution of their success to their effort and not to other factors unrelated to their performance (D6).

Analyzing factor F3, UPB students are partially in agreement that teachers' qualities have a significant influence on the teaching-learning process (D7), indifferent to partially agreeing that the different methodologies used influence the teaching-learning process of mathematics (D8) and partly agreeing to agree that the relationship with his teacher is the most influential dimension. (D9).

Observing factor 4, there is an indifferent to moderate interest of the parents or siblings because UPB students do well in math (D10), but a higher expectation about their performance (D11), little interest from friends (D12), a high feeling that success and good economic status will be achieved by mastering mathematics (D13) and an indifferent perception of stereotypes (D14).

Describing factor 5, UPB students are indifferent or partially agree that the degree of perseverance (D15), level of satisfaction and curiosity (D16), and level of anxiety and frustration (D17) can significantly influence In the learning of mathematics.

Finally, factor F6 has the highest perception scores with respect to other factors, indicating that UPB students perceive that they are very satisfied in their training in mathematics and that the mathematics studies carried out have allowed them to change of their vision towards this area of study.

Changes in the assessment of mathematics training

Students' valuation of their math training should increase as they study subjects with more difficult content. To verify this assumption, a randomized block ANOVA was performed, where the factor to be considered is the type of subject that the student is studying and the block variable is the item considered for evaluation. The response variable is the average score assigned by the students to each item with the scale of the instrument (1 to 7).

The data for the analysis are shown in Table 13.

Table 13: Experimental data on the average valuation of mathematics training

Subject	P71	P72	P73	P74	P75	Mean	Variance	CV
Introduction to mathematics	4.70	5.00	5.03	4.57	5.33	4.93	0.09	6.12
Linear algebra	4.62	5.00	5.57	5.33	5.86	5.28	0.23	9.17
Mathematics I	5.16	5.18	5.33	4.93	5.52	5.22	0.05	4.21
Mathematics II	4.93	5.29	5.21	5.43	5.43	5.26	0.04	3.91
Mathematics III	4.50	4.95	4.90	4.90	5.50	4.95	0.13	7.21
Mean	4.78	5.08	5.21	5.03	5.53			
Variance	0.07	0.02	0.07	0.12	0.04			
CV	5.49	2.81	5.00	6.97	3.58			

Table 14 shows the results of the analysis of variance performed. We conclude that the type of material has a significant influence on the assessment score in mathematics training and that the scores of each factor 6 item differ in their assessment.

Table 14: ANOVA of blocks of training scores in mathematics

Origin of variations	Sum of squares	Degrees of freedom	Mean sum of squares	F	P value	Conclusion
Rows (subject)	0.6001	4	0.1500	3.5390	0.0299	Reject Ho
Columns (item)	1.4937	4	0.3734	8.8088	0.0006	Reject Ho
Error	0.6783	16	0.0424			
Total	2.7721	24				

In order to observe more precisely the differences between the scores of the subjects and the items, in Tables 15 and 16 the multiple range test of the least significant difference (LSD) is performed.

Table 15: LSD for mathematics training items

Contrast	Sig.	Difference	+/- Limits
1 - 2	*	-0.302	0.276
1 - 3	*	-0.426	0.276
1 - 4		-0.250	0.276
1 - 5	*	-0.746	0.276
2 - 3		-0.124	0.276
2 - 4		0.052	0.276
2 - 5	*	-0.444	0.276
3 - 4		0.176	0.276
3 - 5	*	-0.320	0.276
4 - 5	*	-0.496	0.276

BLOCK	Mean	Sigma	Homogeneous Groups
1	4.782	0.092	X
4	5.032	0.092	X X
2	5.084	0.092	X
3	5.208	0.092	X
5	5.528	0.092	X

Item 75 has the highest average score. Between items 72, 73 and 74 there are no significant differences in average scores. The item with the lowest average score is 71.

It can be concluded that students, at the level in which they are currently in mathematics, perceive that they have not yet completed their expectations of mathematics training. However, the positive aspect is that they have a high appreciation of the importance of mathematics, a sense of receiving good training and have gained new ways of approaching problems.

Table 16: LSD for mathematics training courses

Contrast	Sig.	Difference	+/- Limits
Introduction to mathematics - Mathematics I	*	-0.298	0.276267
Introduction to mathematics - Mathematics II	*	-0.332	0.276267
Introduction to mathematics - Mathematics III		-0.024	0.276267
Introduction to mathematics - Linear Algebra	*	-0.350	0.276267
Mathematics I - Mathematics II		-0.034	0.276267
Mathematics I - Mathematics III		0.274	0.276267
Mathematics I - Linear Algebra		-0.052	0.276267
Mathematics II - Mathematics III	*	0.308	0.276267
Mathematics II - Linear Algebra		-0.018	0.276267
Mathematics III - Linear Algebra	*	-0.326	0.276267

Subject	Mean	Sigma	Homogeneous Groups
Introduction to mathematics	4.926	0.092	X
Mathematics III	4.950	0.092	X X
Mathematics I	5.224	0.092	X X
Mathematics II	5.258	0.092	X
Linear Algebra	5.276	0.092	X

Matters that have the lowest score in the perception of training in mathematics are an introduction to mathematics and mathematics III. The subjects that score higher are linear algebra, mathematics I and mathematics II. In mathematics II, not only a higher average score is achieved than in mathematics I, but its percentage variation is much lower.

As you can see the assumption is met in part, since there is the exception in mathematics III, which should have the highest average of all. The reasons why mathematics III has a score significantly equal to introduction to mathematics, instead of having a high score could be the following:

- The students, when attending the different subjects of mathematics, realize that they need more training courses in mathematics, since they begin to apply them in other subjects of their education; however, when they reach mathematics III with the expectation that their content will continue to help them in their training, this is insufficient.
- The mathematics III course does not have a well-defined content, objective and plan, in order to consolidate a significant contribution to student training.

UPB student academic profile with beliefs, attitudes, emotions and positive valuations about mathematics

Analysis design

An analysis was made of the influence of academic and personal variables on the beliefs, attitudes and values of UPB students about mathematics. The scheme of study is shown in Figure 3.

The input variables are: gender and age, as personal variables, and campus, faculty, semester, scholarship, subject, repeater condition and repeated subject, as academic variables. The response variables are the 6 factors about beliefs, attitudes and valuation in training about mathematics.

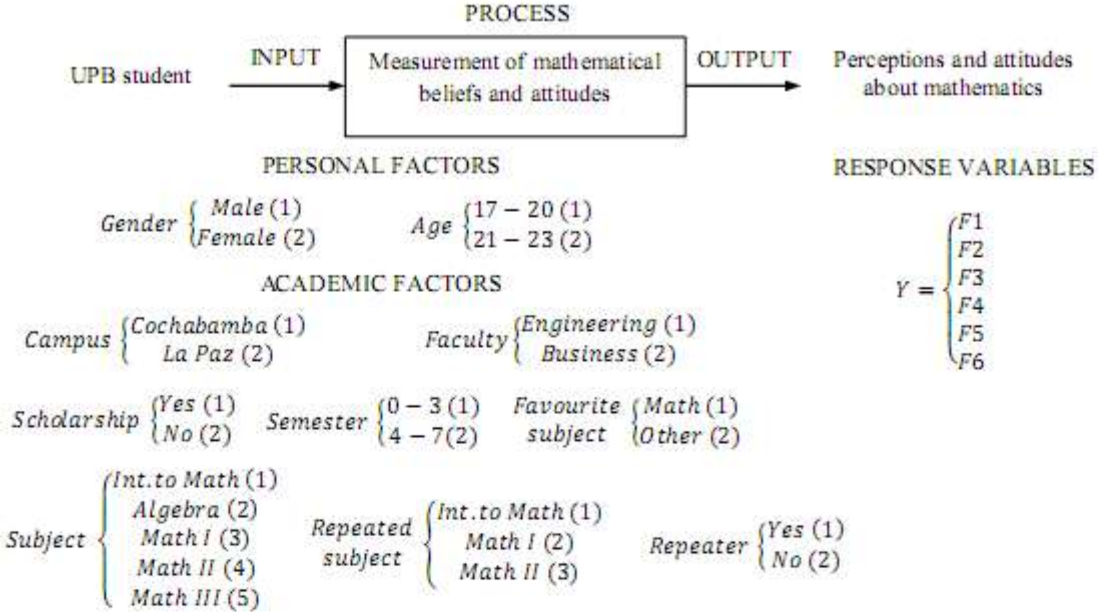

Fig-3: Scheme of analysis for the academic profile of the student of the UPB about the beliefs, attitudes and valuation in training about mathematics

Performed analyzes

The statistical analysis was performed for the variable "repeated subject", as an example of what was done with each of the input variables.

Below is shown in Table 17, ANOVA analysis for the six factors of the research with the input variable repeated subject.

Table 17: Results of the ANOVA for the input variable repeated subject

Factor	Source of variation	Sum of squares	df	Mean sum of squares	F	Sig.
F1	Intergroups	0.797	3	0.266	0.592	0.621
	Intragroups	87.980	196	0.449		
	Total	88.777	199			
F2	Intergroups	1.987	3	0.662	1.654	0.178
	Intragroups	78.487	196	0.400		
	Total	80.473	199			
F3	Intergroups	2.295	3	0.765	1.162	0.325
	Intragroups	129.031	196	0.658		
	Total	131.327	199			
F4	Intergroups	0.910	3	0.303	0.714	0.544
	Intragroups	83.256	196	0.425		
	Total	84.166	199			
F5	Intergroups	4.867	3	1.622	2.175	0.092
	Intragroups	146.158	196	0.746		
	Total	151.025	199			
F6	Intergroups	1.047	3	0.349	0.284	0.837
	Intragroups	240.744	196	1.228		
	Total	241.791	199			

The type of matter repeated by the student of the UPB does not affect significantly in any factor. However, factor F5 can be analyzed, since the level of significance is about 0.05.

Table 18 shows the statistics for the different levels of repeated subject per factor.

Table 18: Statistics for each level of repeated subject by factor

Factor	Levels	N	Mean	SD	Factor	Levels	N	Mean	SD
F1	1	18	4.65	0.67	F4	1	18	4.61	0.64
	2	20	4.70	0.64		2	20	4.53	0.54
	3	13	4.90	0.70		3	13	4.57	0.68
	4	149	4.82	0.67		4	149	4.72	0.66
	Total	200	4.80	0.67		Total	200	4.68	0.65
F2	1	18	4.52	0.59	F5	1	18	4.52	0.78
	2	20	4.46	0.48		2	20	4.18	0.72
	3	13	4.37	0.62		3	13	4.39	1.18
	4	149	4.68	0.66		4	149	4.67	0.86
	Total	200	4.62	0.64		Total	200	4.59	0.87
F3	1	18	4.88	0.97	F6	1	18	5.14	1.34
	2	20	4.73	0.79		2	20	5.10	1.12
	3	13	5.22	0.62		3	13	5.43	1.32
	4	149	4.81	0.81		4	149	5.15	1.06
	Total	200	4.84	0.81		Total	200	5.16	1.10

Table 19 shows the results of the multiple range test of the least significant difference, applied to the levels of repeated subject in factor F5.

Table 19: Difference of means of repeated subject levels for factor F5

Factor	Difference of means	Value	Sig.
F5	1-2	0,342	0,225
	1-3	0,124	0,694
	1-4	-0,148	0,494
	2-3	-0,218	0,479
	2-4*	-0,490	0,018
	3-4	-0,271	0,279

Students who have repeated introduction to mathematics, mathematics II or have not repeated any subject have attitudes and emotions towards mathematics more positive than students who have repeated math I.

RESULTS

The results of the UPB student's profile regarding his beliefs, attitudes and valuation in mathematics training are shown in Table 20.

Table 20: Profile analysis results

Input variable	Factors influenced by the input variable (according to ANOVA and LSD)	Winning levels
Gender	F4	Female
Age	-	-
Campus	F4	Cochabamba
Faculty	F5	Engineering
Semester	-	-
Scholarship	F1 F2	Scholar Scholar

	F5 F6	Scholar Scholar
Subject in progress	F1 F2 F3 F5	Algebra, math I, II y III Algebra Algebra and math II Algebra and int. to math
Repeater condition	F2 F5	Has not repeated Has not repeated
Preferred subject in the module	F1 F2 F5	Mathematics Mathematics Mathematics
Mathematics subject you are repeating	F5	Int. to math, math II or neither

Gender only affects factor F4 (beliefs aroused by the socio-familial context). It can be observed that for the factor F4, the female students have the most positive beliefs towards the mathematics raised by the socio-familial context.

It can be observed that the student's age does not have a significant effect on the factors studied.

The campus in which the student is enrolled significantly affects the F4 factor. It can be observed that for the F4 factor the student of the Cochabamba campus is the one that presents higher scores on his beliefs raised by the sociofamiliar environment.

The faculty in which the student is enrolled has a significant effect on factor F5 (attitudes and emotions toward mathematics). Engineering students are those who have more positive attitudes and emotions toward mathematics than business students.

The semester that is studying the student of the UPB has no significant influence on any factor.

A student's status as a trainee has a significant effect on the factors F1 (Beliefs about the nature of mathematics, his teaching and learning), F2 (Beliefs as an apprentice of mathematics), F5 (Attitudes and emotions toward mathematics), and F6 (value of training in mathematics). Student trainees are those who present beliefs about the nature of mathematics, their teaching and learning, beliefs as an apprentice of mathematics, attitudes and emotions toward mathematics, and a valuation of mathematics training that are much more positive than non-fellows. This finding supposes that the scholarship recipients are more magnanimous in evaluating the training received in the UPB in mathematics, precisely because of their condition of receiving financial aid in their tuition and a sense of retribution to the institution.

The type of mathematics subject currently being studied by the UPB student significantly influences factors F2 (beliefs as a mathematics learner), F3 (beliefs about the role of the mathematics teacher) and F5 (attitudes and emotions towards mathematics). Although in the ANOVA the F1 factor was not significant, if it was significant in the LSD test.

Students in linear algebra, math I, II, and III have scores of beliefs about the nature of mathematics and the teaching-learning process higher than students in the subject of introduction to mathematics. Students in linear algebra have higher scores on their positive beliefs as math learners compared to students in other math subjects. Students in linear algebra and math II have higher positive perceptions regarding their beliefs about the teacher's role in teaching received than students in other math subjects. Students of introduction to mathematics and linear algebra have more positive attitudes and emotions toward mathematics than students of other subjects.

The repetitive status of some UPB students mathematics matter significantly influences factors F2 (beliefs as an apprentice of mathematics) and F5 (attitudes and emotions towards mathematics). The student who has not repeated any mathematical subject to date, is the one who presents beliefs as an apprentice of mathematics and attitudes and emotions towards mathematics more positive than students who have repeated a subject.

The preferred type of subject matter of UPB students significantly influences factor F5 (Attitudes and emotions toward mathematics). However, F1 (beliefs about the nature of mathematics, its teaching and learning) and F2 (beliefs as an apprentice of mathematics) are close to significance. Students who have expressed that their favorite subject in the module is mathematics, present attitudes and emotions toward mathematics, beliefs about the nature of mathematics, beliefs about teaching and learning mathematics, and beliefs as an apprentice of math, far more positive than students that have other favorite subject that is not mathematics.

Therefore, the profile of the student of UPB with beliefs, attitudes and valuation in their most positive training is the following: woman who studies in the campus Cochabamba in the faculty of engineering, scholarship holder, that studies the subject of linear algebra, which does not has repeated no mathematics subject and whose preferred subject in the module is mathematics.

CONCLUSIONS

An empirical study was carried out with the purpose of measuring different aspects about beliefs, attitudes and valuation in mathematics training. For this purpose, information was collected through a survey of 200 students from the Bolivian Private University of the Cochabamba and La Paz Campuses.

A survey was designed consisting of a questionnaire with 75 items, 6 factors (three of different beliefs, one of attitudes and emotions and one of the assessment in the formation of mathematics) and several dimensions in each of the factors). This questionnaire was based on the classification proposed by Caballero and Blanco [1] and Caballero, Guerrero and Blanco [2] and was elaborated taking into account the contribution of many researchers, but especially Gil *et al.* [59]. The dimensional structure of each factor was tested using confirmatory factorial analysis (CFA), resulting in generally good fit indices in all factors, with the exception of F2 factors (beliefs about oneself as an apprentice of mathematics) And F5 (emotional attitudes and reactions about mathematics).

Through the structural equation modeling (SEM) it was found that factor F3 (beliefs about the role of teachers in mathematics teaching) was the only one that had a direct and significant effect on factor F6 (value of mathematics training) and is the most significant (0.689). Factor F2 (beliefs as an apprentice of mathematics) was next in influence with an indirect effect, through factor F3. Factors F1 (beliefs about the nature of mathematics) and F4 (family beliefs about mathematics) had much weaker indirect effects. Finally, factor F5 (attitudes and emotions towards mathematics) had no significant effect on the assessment of the training received. This shows that the students are very influenced by the role of the teacher in teaching to value their learning more positively.

As the factorial structure of the battery of measurement of the different beliefs, attitudes and valuation in mathematics training had disadvantages in the indices of goodness of fit in the factors F2 and F5, through the exploratory factorial analysis a more parsimonious battery was proposed, eliminating several items and dimensions, obtaining an instrument with 6 factors, 10 dimensions and 31 items.

Subsequently, we analyzed the average scores obtained by UPB students in each factor and dimension. In general the results show that in all factors the score is in the range of 4 to 5, showing that the students are indifferent to partially agreeing on their beliefs and positive attitudes about the mathematics that they attend in the university (in a scale of 1 to 7), with the exception of factor F6 (assessment of training received in studies in relation to mathematics) which was rated in the range of 5 to 6, i.e. between partially according to strongly agree, showing that UPB students are quite satisfied with their training in mathematics.

It was also checked whether the assessment in the training received in mathematics of the students of the UPB follows a gradual increase as they go studying math subjects, from pre-university level to the last level. For this purpose, a randomized block ANOVA was performed, in which the input variables were the mathematics subjects to be studied by the student and the items that make up the factor F6. The response variable was the perception scores given by the student sample. Additionally, the least significant difference (LSD) test was used to test the significance of the comparison between means of the different levels of the input variables. The results showed that item 71 had the lowest average score, items 72, 73 and 74 had similar average scores and item 75 was the one that obtained the highest average score, indicating that UPB students did not yet complete their expectations With respect to the training received in mathematics, but value more than before the importance of mathematics in their academic training. On the other hand, it was verified that the assumption is not fulfilled that when going to mathematics subjects of increasing complexity the student values a more positive form, since in mathematics III a similar score was obtained that in the introductory course in mathematics.

Finally, through the ANOVA analysis and the multiple rank tests, a personal and academic profile of the student of the UPB was obtained with beliefs, attitudes and valuation in his training about the mathematics, more positive: female, student, engineering student at the Cochabamba campus, who has not repeated no matter of mathematics and rather it is its favorite subject and that at the moment it studies the matter of Linear Algebra.

IMPLICATIONS IN THE MANAGEMENT

The findings of this research can have important consequences in the improvement of the academic management of the UPB, if they are taken into account in the design and implementation of future programs.

First, academic management now has a validated tool for measuring beliefs, attitudes and values in the training received from the student point of view to calculate the impact of the programs that will be carried out in the improvement of the teaching of mathematics.

Second, taking into account the scores obtained in each specific factor and dimension, programs can be designed in order of priority to try to raise the scores with lesser value. For example, the factor that had the lowest score is F4 (beliefs raised by the socio-family environment), with dimension D12 (interest of peers / friends). Knowing this fact, an incentive program could be carried out to ensure that in the subjects of mathematics the work in groups is promoted and there are practices to include the use of mathematics in the daily activities carried out by the group of friends.

The fact that the role of the teacher and the beliefs as a learner of mathematics of the student are vital in the student's perception of value in their formation, can lead to establishing programs that encourage a teacher-student protagonist balanced in teaching, introducing greater training in mathematics didactics, new strategies, methodologies and working methods, novel forms of evaluation, etc.

Finally, consideration of the results of the student's personal and academic profile with positive beliefs and attitudes toward mathematics may lead to specific improvement programs in different campuses, faculties and mathematics subjects. For example, the results showed that programs must be carried out to raise different aspects of teaching in mathematics at the La Paz campus, in the Faculty of Business Sciences and in mathematics III.

FUTURE RESEARCH

There are several aspects that this research has not been able to include and that should be considered for future research.

In order to obtain an SEM model with greater explanatory power, it is necessary to investigate further the antecedent constructs that influence the evaluation in mathematics training, since the model analyzed had a moderate predictive power (47.5%).

Since the role of teacher and beliefs as an apprentice of mathematics are crucial for a more positive assessment in student formation, other variables that can influence, such as the student's GPA, the perception of complexity can be included in the student's profile of the course, etc. On the other hand, one could investigate the establishment of a teacher profile that influences positively in order to achieve higher perceptions of student formation. Variables such as gender, marital status, age, experience in teaching, methodology used, and contractual conditions of teachers, could be analyzed.

Finally, other applied mathematics subjects such as numerical analysis, differential equations, statistics, financial mathematics, etc., can be included in the study to see if they increase the valuation score on student training in mathematics.

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Appendix

Questionnaire of beliefs, attitudes and valuation in training about mathematics

Factor	Dimension	N°	Items
F1	D1	1	Mathematics is useful and necessary in all areas of life
		2	The skills or abilities I use in class to solve problems have nothing to do with the ones I use to solve problems in my daily life
		3	Good math training is a great advantage to access any type of work
		4	Mathematics make you think logically and systematically and teach you to be disciplined
		5	I will keep my notebooks or math texts because they will probably serve me
	D2	6	Mathematics is difficult, boring and far from reality
		7	In mathematics it is fundamental to learn from memory the concepts, formulas and rules
		8	The result I get after trying to solve a problem is more important than the process I followed
		9	I wish they had never invented mathematics
	D3	10	The best way to learn math is through individual study
		11	When teachers propose us group work there is usually a high level of interest and participation in class
		12	It is important to learn different strategies to solve the same problem
		13	Routine exercises are very important in learning mathematics
		14	The time taken to understand why a solution works is a well-spent time
F2	D4	15	I have confidence in myself when I face math problems
		16	I have many deficiencies in mathematics, it is not one of my strengths
		17	I have a mathematical mind
		18	In math I settle for approving
	D5	19	The taste for mathematics influences when choosing a particular career in which they are not present
		20	Being a good student in math (good grades, good attitude) makes me feel more admired and appreciated by my classmates
		21	If I do not understand mathematics, I could hardly assimilate and master other related subjects (such as physics, chemistry, statistics, etc.)
		22	I need to do well in math to get the job I want
		23	Studying mathematics helps me solve problems in other areas
	D6	24	My performance in math depends largely on the teacher's attitude toward me
		25	When I spend more time studying mathematics I get better results in problem solving
		26	When I try to solve a problem, I usually find the correct result
		27	Luck influences when it comes to successfully solving a math problem
F3	D7	28	Mathematics teachers are always ready to help and clarify the doubts and difficulties that arise during the class
		29	Mathematics teachers are interested in my evolution and performance in the subject
		30	In mathematics class teachers value my effort and recognize my daily work in the subject
		31	The teacher encourages me to study more mathematics, advises me and teaches me to study
		32	The teacher is too good in mathematics, such that he cannot explain clearly
	D8	33	In mathematics class teachers use a variety of means and practical examples that allow me to relate mathematics to situations of my daily life
		34	The methods of mathematics teachers are often more boring than those of other subjects
		35	After each evaluation, the teacher comments on the progress made and the difficulties encountered
		36	I better understand a mathematical concept when the teacher presents specific examples
		37	Calculators and computers help you learn math better
	D9	38	My relations with math teachers are satisfactory
		39	I get on well with my math teacher

Questionnaire of beliefs, attitudes and valuation in training about mathematics (Continued)

Factor	Dimension	N°	Items
F4	D10	40	Some of my parents or siblings encourage me and help with math problems
		41	The math that we are taught at the university does not interest my parents
		42	My parents were pretty good at solving math problems
		43	Mathematics in my family is a subject that they consider very important
		44	The importance of math competence has been emphasized in my home
	D11	45	Some of my parents expect good results in math
		46	My parents will be disappointed if I do not do well in math
	D12	47	My friends spend mathematics
	D13	48	Mathematics is important because the economically most paid professions are related to them
		49	Increasing my mathematical knowledge will make me feel competent in society
		50	Mastering mathematics will allow me to succeed in my later studies
	D14	51	People who like math are usually a little weird
		52	Math is for smart and creative heads
		53	People who are good at math do not have to spend time figuring out how to solve a problem
		54	Everyone can learn math
		55	They make fun of girls if they are good at math
F5	D15	56	Faced with a complicated problem I usually give up easily
		57	When in the math class a question or problem is left unanswered, I keep thinking about it
		58	I do not like tasks that I cannot solve immediately
		59	I can spend hours studying math and doing exercises
		60	I do not settle for giving a result, I want to be sure that I give it well and why I do it well
	D16	61	I enjoy the days that I do not have math classes because they do not interest me or attract me
		62	When I am facing a problem, I am very curious about the solution
		63	When solving problems in a group I have more confidence in myself
		64	I find that mathematics is a very interesting and exciting subject
		65	I like mathematical puzzles
	D17	66	I am distressed and afraid when the teacher asks me by surprise to solve a problem
		67	When I get stuck or blocked in solving a problem I begin to feel insecure, desperate, nervous ...
		68	I'm afraid I'm not able to keep up with math class
		69	My mind goes blank and I cannot think clearly when I work in mathematics
		70	I am always under a terrible stress in a math class
F6	D18	71	My expectations for my training in mathematics were fulfilled
		72	I have discovered other ways of approaching mathematical problems
		73	I feel qualified with my training in mathematics
	D19	74	My university studies have changed my perception of mathematics
		75	As a university student, I value the importance of mathematics more positively than before