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University Students' Rejection to Learning Statistics: Research from a Latin American Standpoint

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Abstract

Introduction: Negative beliefs, fear, avoidance behaviors, and superficial attitudes surrounding the learning of statistics create significant problems for university students in Latin America. *Objective:* To analyze the impact of fearful behavior, superficial work, and avoidance displayed by university students when it comes to statistics. *Method:* In this article, we give details about a quantitative research project carried out by two independent studies. The first (N = 310) focused on the development of a scale to assess negative beliefs, fears, and avoidance behaviors towards statistics, in which goodness of fit was determined in a 3-factor model. In the second study (N = 250), it was hypothesized that undergraduates perform superficially due to negative beliefs and avoidance behaviors when learning statistics. *Findings:* The proposed model explained 42% of the variance. In addition, in the analysis of the proposed mediation model, an adequate adjustment was found. In the discussion of this research project, the need to intervene in the negative beliefs, fears, and avoidance behaviors displayed by university students towards statistics is highlighted. *Novelty:* This research project explains why college students dislike or avoid learning statistics in depth. The findings will allow for a modification in the way statistics is taught so that Latin American professionals achieve better performance in this field.

Keywords:

Anxiety Over Statistics;
University Students;
Avoidance Behavior Towards Statistics;
Negative Beliefs Towards Statistics;
Superficial Attitudes Towards Statistics.

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1- Introduction

Learning and understanding statistics is a crucial topic for 21st-century societies. Contemporary societies, through their organizations, generate an enormous amount of information and big data. This implies that people, whether in the role of professionals or citizens, must have knowledge of statistics to be able to process and interpret this data and make better decisions for their lives and workplaces. While the attitude of citizens in general towards statistics is interesting, the attitude of university students, who are to be future professionals and scientists, is of particular interest. Previous studies carried out on the attitudes of university students toward statistics yielded very interesting results. In Spain, the positive attitude of students towards learning statistics decreases as the number of years of study increases [1]. Additionally, students in higher education present difficulties in understanding the correct application of statistical techniques in research [2]. In the United States, there is significant anxiety and a lack of motivation and interest on behalf of students when they must learn statistical concepts and pass this subject [3–8].

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In other countries, such as Malaysia, undergraduate students feel intimidated, fearful, and stressed when solving problems related to statistics [9]. In Iran and the UK, graduate students find it difficult to understand statistics and have even found it frightening to present their doubts in front of statistics teachers, resulting in low academic performance [10, 11]. In the Latin American context, which is the focus of this research, some data from previous studies show a complex panorama since weaknesses are identified at a quantitative level starting in secondary school. For example, high school students often get the worst grades on math exams before entering the university [12], consequently beginning their professional lives with serious shortcomings in the quantitative area. This problem gravitates towards how this affects higher and professional education, where an impact and stagnation can be observed in the scientific development of a country, as in Latin America, where there are few scientific publications with statistical data [13–16]. Additionally, in Latin America, the lack of results or scientific studies in this line of research highlights the limitations in the use of statistics, in addition to the fact that, in this context, university students present high levels of fear, avoidance, and dislike towards statistics, as in European countries and North America [16]. The above-described situation invites us to reflect upon our region, for which we hope to delve into the study of attitudes and behaviors towards statistics and their interrelationships at the university level.

To carry out this research, we wanted to analyze the relevance of creating an instrument to measure beliefs and fears about statistics and statistical avoidance. This arose after having carried out a review of instruments and not having found a suitable method for our needs. Apropos, the existing methods used to measure the subject herein researched have been oriented to measure anxiety towards statistics. The scales that exist to measure aspects of fear or anxiety towards statistics are the STARS Questionnaire, the Statistics Anxiety Inventory, the Inventory for Measuring Anxiety in Statistics, the Zanakis and Valenzi Scale, the Measurement of Anxiety in Statistics, the Statistical Anxiety Scale, the Scale of Attitudes towards Statistics, and the Scale to Analyze Statistical Difficulties.

Although the reviewed scales intend to measure the anxiety component involved in learning statistics, in many cases, they are adaptations of scales that sought to measure anxiety towards mathematics. In our opinion, this generates a serious limitation when applying several of the previous scales, considering that mathematics and statistics involve different quantitative skills. Conversely, in many cases, they are extensive scales, which can generate fatigue due to the time it takes to do them. Finally, most of the scales mentioned above have been developed in the context of the economically developed Anglo-Saxon world.

When the research objective was achieved and the field study and data analysis that gave way to the SABS scale (as will be described below in the method) were completed, the need arose to conduct a new study that would allow for an explanatory model for a deeper understanding of the consequences of negative beliefs and statistical avoidance behaviors. In this sense, previous research identified that university students in Latin America are not committed to truly learning statistics. Nonetheless, they are able to pass this subject with minimal grades or with remedial processes, which makes them advance in their career but without statistical skills [17]. Therefore, in a second study, we analyzed the relationship between the variables of negative beliefs, avoidance behaviors, and superficial work in statistics and hypothesized that it would be latent. This relationship could be generating this non-behavioral behavior in a large percentage of students when it comes to learning statistics, thus impacting the scientific development of a region [18].

This research project, along with the two reported studies, has the following objectives: (a) to develop a scale appropriate for the Latin American standpoint that measures constructs related to the attitudes and behaviors of university students towards statistics; and (b) to propose an explanatory model about the interaction of the variables related to negative beliefs, avoidance behaviors, and superficial work towards statistics.

1-1- Research Scenario

This research was conducted in Ecuador, a South American country with more than 16 million inhabitants. The economic system is capitalist, with the North American dollar as the official currency. Its educational system seeks to meet regional and world standards, with universities accredited to international standards. The country is culturally collectivist, with a mostly Catholic population and economically developing characteristics, which it shares with other Latin American countries. This cultural and economic similarity between Ecuador and neighboring Latin American countries creates great potential for the results of this study to be useful for the entire region and even for developing countries in other regions. Figure 1 shows the method followed in this investigation.

2- First Study

2-1- Research Hypotheses

H1: A SABS scale (Scale of Attitudes and Behavior towards Statistics) has a correct fit with two factors: (a) attitudes towards statistics and (b) behavior towards statistics.

H2: Attitudes towards statistics are correlated and have an important degree of causality with behavior towards statistics.

H3: There are no significant differences in the level of attitudes and behaviors towards statistics, according to gender and age group.

H4: There are statistically significant differences in attitudes and behaviors towards statistics when comparisons are made based on a person's like or dislike of statistics.

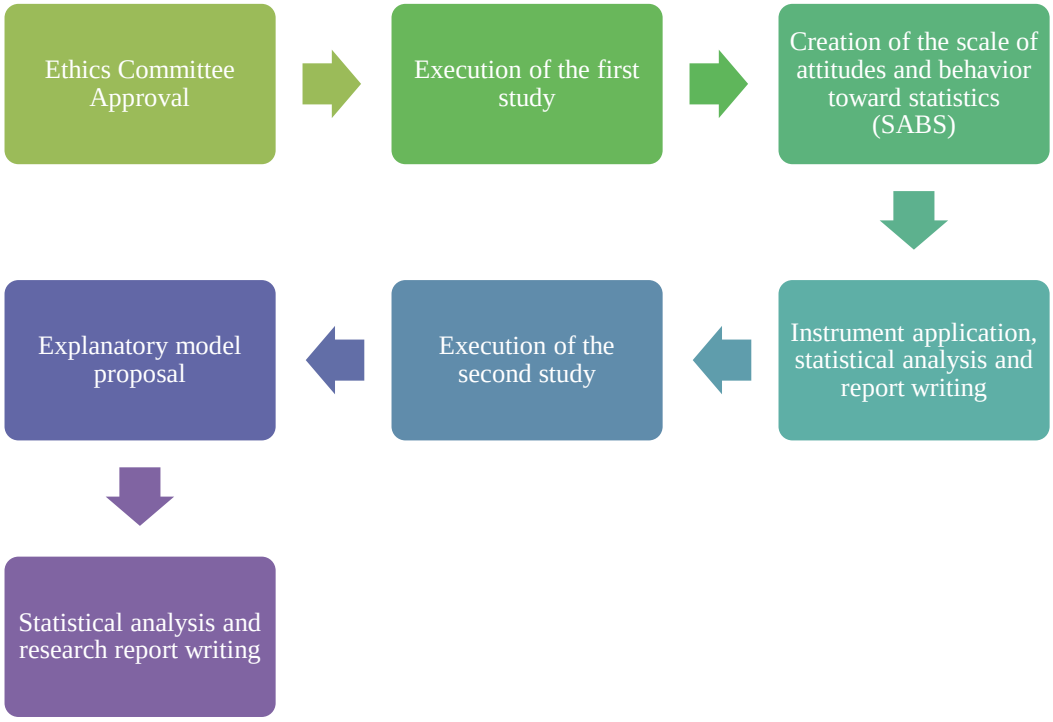

Figure 1. Research method flowchart

2-2- Methods

2-2-1- Participants

We worked with a probability sample of 310 university students from 15 cities in Ecuador. The sample consisted of 83 men (26.8%) and 227 women (73.2%). In terms of age range, there were 271 (87.4%) students between the ages of 18 and 25, 25 (8.1%) between the ages of 26 and 30, 11 (3.5%) between the ages of 31 and 35, 2 (0.6%) between the ages of 36 and 40 and 1 (0.3%) between the ages of 46 and 50.

2-2-2- Procedure

This study was approved by the ethics committee of the university where one of the authors works. At all times, this research complied with the ethical standards for research with human beings according to the Declaration of Helsinki, for which the physical and psychological integrity of the participants was safeguarded, and absolute confidentiality was maintained for the data obtained in the research [19].

To measure in the first study, a Scale of Attitudes and Behavior towards Statistics (SABS) was created, which began with by creating the possible items. This group of items was produced by the authors of the study and was subsequently refined by submitting it to expert judgment, cognitive interviews with university students and a pilot study. Table 1 presents the resulting scale.

The final SABS scale consisted of 14 items (Table 1), organized in a first stage into two factors: (a) negative beliefs towards statistics, items 1–7, and (b) anxiety towards statistics, items 8–14. However, as presented later, the three-factor scale had a better fit, with the three factors being: (a) negative beliefs towards statistics (items 1–7), (b) fear of statistics (items 8–11), and (c) avoidance behaviors towards statistics (12–14). Once the scale was finalized, a database of the study population was generated for sampling purposes. Students were randomly selected from different universities in Ecuador and asked to sign a voluntary participation consent form. Subsequently, the survey was applied by means of a multimedia system created for this research. As a result, 310 people completed it, and usable responses were obtained.

Table 1. Scale of attitudes and behavior towards statistics (SABS)

Items	Frequency			
1. I believe that statistics is not important in my professional training.	T/D	M/D	P/A	T/A
2. Knowing statistics is irrelevant to my training.	T/D	M/D	P/A	T/A
3. Running statistical analyses are not important in my professional career.	T/D	M/D	P/A	T/A
4. I consider statistics useless in my profession.	T/D	M/D	P/A	T/A
5. I think that statistics are not important for doing research.	T/D	M/D	P/A	T/A
6. Statistics is not a tool for interpreting reality.	S/D	M/D	P/A	T/A
7. I tend to reject statistics, even when I do not know what their content is.	T/D	M/D	P/A	T/A
8. At the onset of a statistics course, I have been afraid because of the content I have to learn.	T/D	M/D	P/A	T/A
9. I feel fear when I am asked to perform work involving statistical analysis.	T/D	M/D	P/A	T/A
10. When I hear the concepts of mean, standard deviation, variance, ANOVA and multiple regression, I cringe.	T/D	M/D	P/A	T/A
11. I feel changes in my body (sweating hands, body tremors, shortness of breath, increased heart rate, muscle tension) when I have to attend a statistics class or activity.	T/D	M/D	P/A	T/A
12. I tend to avoid doing statistical tasks.	T/D	M/D	P/A	T/A
13. In my university education, I have missed statistics classes more often than classes in other subjects.	T/D	M/D	P/A	T/A
14. I look for excuses not to attend activities involving statistics.	T/D	M/D	P/A	T/A

Note. T/D: Totally Disagree, M/D: Moderately Disagree, P/A: Partially Agree and T/A: Totally Agree.

2-2-3- Data Analysis

First, a descriptive statistical analysis of central tendency and dispersion was applied to characterize the sociodemographic variables. To analyze the factorial structure of the scale, confirmatory factor analysis was applied. Mean comparison techniques were used to establish the differences between nominal and ordinal variables in the sample. Finally, the causal associations and predictions between the variables were analyzed by applying correlation and regression techniques. The analyses were performed using SPSS version 24 and AMOS version 22 statistical packages.

2-3- Results

2-3-1- Confirmatory Factor Analysis

As part of the confirmatory factor analysis, three models were tested, with one (Figure 2), two (Figure 3) and three factors (Figure 4). From the obtained results, the three-factor model had the best goodness-of-fit (Table 2).

Table 2. Confirmatory factor analysis indicators

Model	x^2	*Cl*	*CFI*	*RMSEA* (95% IC)	*SRMR*
1. a	837.06*	77	0.64	0.17 (0.16–0.19)	0.12
2. b	565.23*	76	0.77	0.14 (0.13–0.15)	0.10
3. c	352.10*	74	0.90	0.10 (0.08–0.12)	0.07

Notes. DF = degrees of freedom; RMSEA = Root Mean Square Error of Approximation; 95% CI = confidence interval; SRMR = Standarized Root Mean-Square; CFI = Comparative Fit Index. a. One-factor model: Rejection of statistics. b. Two-factor model: Negative beliefs associated with statistics and anxiety about statistics. c. Three-factor model: Negative beliefs associated with statistics, fear of statistics, and avoidance behaviors towards statistics. *p < 0.01.

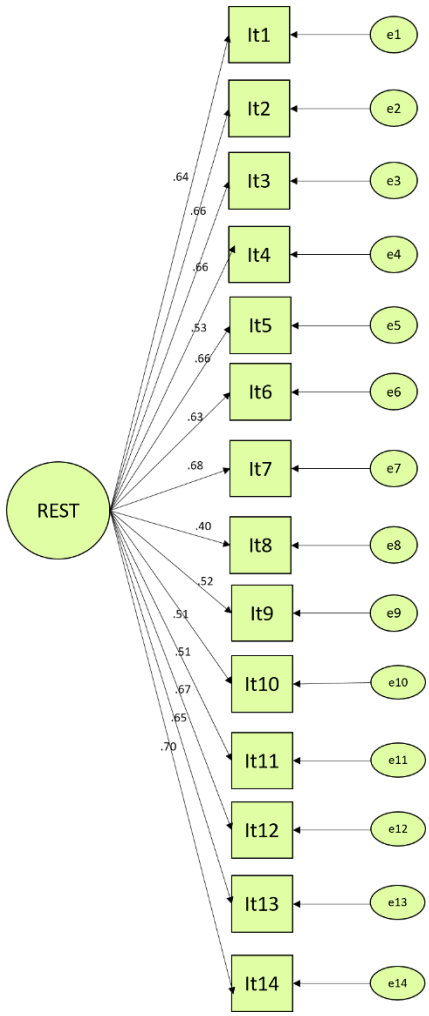

Figure 2. One-Factor model. rest: rejection of statistics

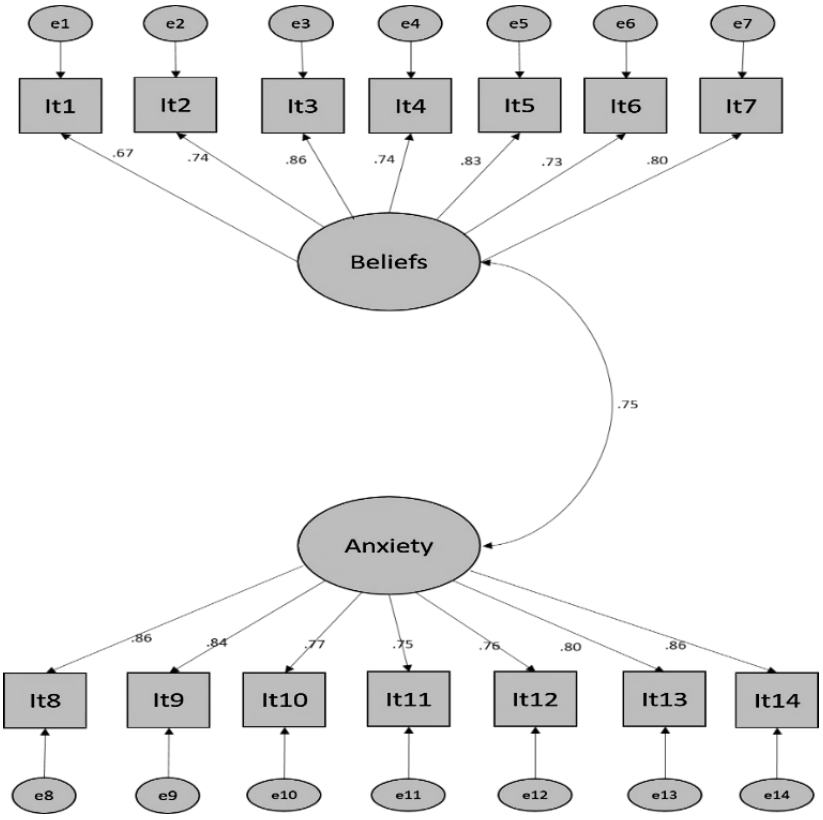

Figure 3. Two-Factor model: negative beliefs towards statistics and anxiety about statistics

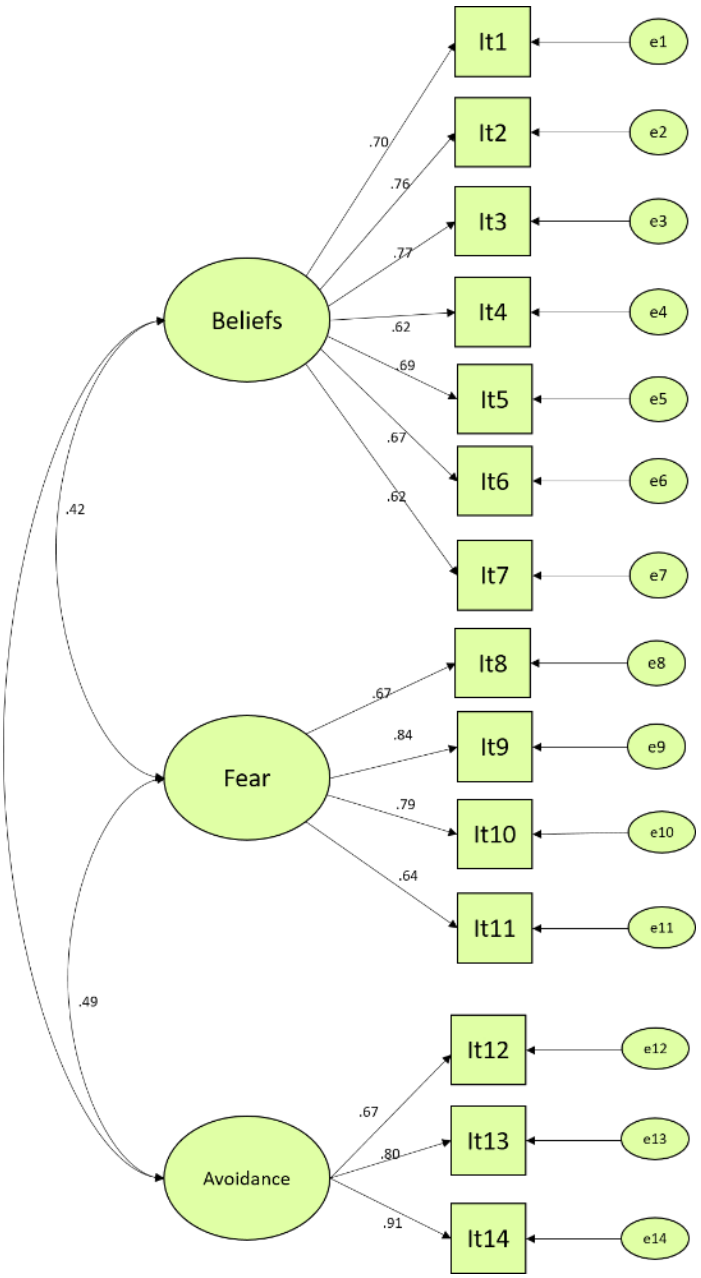

Figure 4. Three-Factor model: negative beliefs towards statistics, fear of statistics and statistics avoidance behaviors

2-3-2- Internal Consistency

Subscale for Negative Beliefs towards Statistics: This subscale consisted of items 1–7. Cronbach's alpha coefficient was 0.86. The correlation between the items on the scale fluctuated between 0.54 and 0.71. Additionally, the internal consistency coefficient did not improve to more than 0.85 with the removal of items; therefore, it was not necessary to eliminate any of the items. Subscale for Fear of Statistics. This subscale consisted of items 8–11. Cronbach's alpha coefficient was 0.82, and it was not necessary to eliminate any item to improve the internal consistency of the scale. The correlation between the items was between 0.55 and 0.73. Subscale for Statistics Avoidance Behavior. This subscale consisted of items 12–14. Cronbach's alpha coefficient was 0.82. The correlation between the items fluctuated between 0.46 and 0.75. As with the previous subscales, it was not necessary to eliminate any items. Table 3 shows the correlation coefficients between each item on the subscales.

2-3-3- Correlation between Subscales

When estimating the relationship between the subscales, a statistically significant association of medium magnitude was found between the three constructs or variables that constitute the SABS. Additionally, the association of each of these constructs with the usefulness that Latin American university students attribute to statistics in their work was analyzed, finding a negative and statistically significant correlation in all cases (Table 4).

Table 3. Correlation between Items of the SABS Subscales

	t1	t2	t3	t4	t5	t6	t7	t8	t9	t10	t11	t12	t13	t14
It1	1													
It2	0.56**	1												
It3	0.51**	0.73**	1											
It4	0.46**	0.43**	0.57**	1										
It5	0.51**	0.48**	0.45**	0.43**	1									
It6	0.47**	0.44**	0.40**	0.44**	0.62**	1								
It7	0.41**	0.42**	0.44**	0.34**	0.42**	0.47**	1							
It8	0.22**	0.22**	0.18**	0.07	0.17**	0.12*	0.29**	1						
It9	0.25**	0.27**	0.25**	0.15**	0.23**	0.18**	0.36**	0.59**	1					
It10	0.23**	0.20**	0.21**	0.11	0.26**	0.18**	0.39**	0.54**	0.66**	1				
It11	0.25**	0.27**	0.19**	0.18**	0.27**	0.19**	0.31**	0.37**	0.53**	0.53**	1			
It12	0.34**	0.28**	0.30**	0.23**	0.32**	0.37**	0.49**	0.36**	0.53**	0.55**	0.55**	1		
It13	0.36**	0.37**	0.42**	0.33**	0.49**	0.41**	0.41**	0.14*	0.21**	0.21**	0.28**	0.46**	1	
It14	0.35**	0.37**	0.38**	0.26**	0.40**	0.43**	0.48**	0.26**	0.33**	0.33**	0.37**	0.61**	0.75**	1

** Correlation is significant at the 0.01 level (bilateral); * Correlation is significant at the 0.05 level (bilateral).

Table 4. Correlation and Descriptive Data of the SABS Scale

Factor	1	2	3	4
1. Negative beliefs associated with statistics	1			
2. Fear of statistics	0.36**	1		
3. Statistical avoidance behaviors	0.57**	0.49**	1	
4. Usefulness of statistics in psychology	−0.23**	−0.36**	−0.27**	1

**. The correlation is significant at the 0.01 level (bilateral).

2-3-4- Causality Analysis

For the causality analysis, three possible regression models were estimated. In the first model, negative beliefs towards statistics explained 13% of the variance in the fear of statistics. In the second model, negative beliefs explained 33% of the variance in avoidance behavior toward statistics. In the third model, negative beliefs towards statistics and fear of statistics, as predictors, explained 42% of the variance in avoidance behavior towards statistics. The results are presented in Table 5.

Table 5. Regression Analysis

Model	*F (df)*	*P*	*R*	R^2
1. a	45.05 (1, 308)	< 0.001	0.36	0.13
2. b	151.14 (1, 308)	< 0.001	0.57	0.33
3. c	110.32 (2, 307)	< 0.001	0.65	0.42

Models: a. Predictor variable: negative beliefs associated with statistics and dependent variable: fear of statistics. b. Predictor variable: negative beliefs associated with statistics and dependent variable: avoidance behaviors towards statistics. c. Predictor variables: negative beliefs associated with statistics and fear of statistics, dependent variable: avoidance behaviors towards statistics.

2-3-5- Comparison Analysis

For this analysis, we used the student's like for statistics, categorized in two levels (yes or no), as a comparison variable. As a result, based on students' like for statistics, there were statistically significant differences in their negative beliefs towards statistics, their fear of statistics and their avoidance behaviors towards statistics (Table 6).

Table 6. Comparison of Means of the Subscales According to Students' Like for Statistics

Factors		*N*	*Mean*	*SD*	*T*	*G1*	*Sig.*
Beliefs	Yes	155	10.48	3.71	−7.10	308	< 0.001
	No	155	13.81	4.51			
Fear	Yes	155	8.08	2.80	−6.38	308	< 0.001
	No	155	10.14	2.89			
Avoidance	Yes	155	4.63	1.85	−8.70	308	< 0.001
	No	155	6.81	2.52			

Note. N: participants who responded to this option. Question: Do you like statistics? SD: standard deviation, T: t-test for comparison of means, Gl: degrees of freedom.

Finally, when comparing the variables (constructs) of the SABS subscales according to the gender and age group of the participants, no statistically significant differences were found. The results obtained were: negative beliefs towards statistics $t_{(306)} = -0.99$, $p = 0.32$ (gender) and $F_{(4, 305)} = 0.90$, $p = 0.46$ (age group); fear of statistics $t_{(306)} = -1.01$, $p = 0.31$ (gender) and $F_{(4, 305)} = 0.83$, $p = 0.51$ (age group); and avoidance behaviors towards statistics $t_{(306)} = -0.42$, $p = 0.67$ (gender) and $F_{(4, 305)} = 0.61$, $p = 0.65$ (age group).

3- Second Study

After Study 1 was completed, new participants were recruited to analyze an explanatory model to better understand the dynamics behind disengaged behavior in statistical learning.

3-1- Research Hypotheses

H₁: Negative beliefs towards statistics generate a superficial attitude among university students towards their learning.

H₂: Avoidance behaviors towards statistics play a mediating role in the causal relationship between negative beliefs towards statistics and superficial attitudes towards students' learning.

3-2- Methods

3-2-1- Participants

The sample consisted of 250 students from different public and private universities in Ecuador. Their ages ranged between ages 18 and 29 ($M = 21.01$, $SD = 2.15$). According to gender, 130 students were men (52.0%) and 120 were women (42.0%). The socioeconomic levels of the participants were medium and medium-high.

3-2-2- Instruments

From the Scale of Attitudes and Behavior towards Statistics (SABS) developed in the first study, the scales (a) negative beliefs towards statistics, consisting of 7 items, and (b) avoidance behaviors towards statistics, consisting of 3 items, were assessed. In addition, the scale to measure (c) the superficial attitude of the scale was used [20]. The rating scale for each item was on 4 levels: 0 points when the response was "never", 1 point when it was "sometimes", 2 when it was "almost always", and 3 when the interpretation was "always".

3-2-3- Procedure

The research began after the completion of Study 1, and approval was requested from the Research Department and Ethics Committee of the university where the main author of the project reported in this article works. Surveys were administered in a self-report format and in a distraction-free environment. All participants who completed the survey signed a voluntary participation consent form, and the purpose of the research was explained to them. In addition, a protocol to protect the integrity of the participants was always followed. Once the survey was applied, the data analysis and writing of the research report proceeded.

3-2-4- Data Analysis

Cronbach's alpha, Pearson's correlation, chi-square, and t test procedures were applied in SPSS package version 24. The structural equation procedure was applied in AMOS version 22.

3-3- Results

3-3-1- Reliability and Validity of Measurement

The scale of negative beliefs towards statistics presented a reliability of 0.73, and the correlations between its items ranged between 0.18 and 0.43. The avoidance behaviors scale presented a reliability level of 0.68, and the correlations between its items were between 0.32 and 0.43. The superficial work attitude variable obtained an acceptable consistency ($\alpha = 0.68$), and the correlation between its items was between 0.46 and 0.54.

3-3-2- Descriptive Data and Association with Sociodemographic Variables

Table 7 shows the descriptive values of the sample. No significant differences were found according to the sociodemographic variable of the participants in negative beliefs [$t_{(248)}$ = 0.38, p = 0.69 (gender), x^2 = 203.95, p = 0.77 (age)], avoidance behaviors [$t_{(248)}$ = 0.49, p = 0.62 (gender), x^2 = 102.19, p = 0.39 (age)] and superficial attitude to work [$t_{(248)}$ = 1.29, p = 1.98 (gender), x^2 = 78.92, p = 0.93 (age)].

Table 7. Descriptive analysis

	Mn	*Mx*	*M*	*SD*	*AS*	*CR*
CNE	7.00	28.00	16.28	4.11	0.37	0.94
CEHE	3.00	12.00	6.68	2.21	0.60	−0.15
AST	3.00	12.00	6.46	2.42	0.60	−0.35

Note: CNE (negative beliefs in statistics), CEHE (avoidance behaviors towards statistics), AST (superficial attitude to work), Mn (minimum), Mx (maximum), M (mean), SD (standard deviation), AS (skewness) and CR (kurtosis).

3-3-3- Correlation Analysis

Table 8 shows the correlational values between the different variables evaluated.

Table 8. Correlations

	CNE	CEHE	AST
CNE	1		
CEHE	0.39**	1	
AST	0.38**	0.44**	1

** The correlation is significant at the 0.01 level (bilateral).

3-3-4- Models Tested Using Structural Equations

Two models were analyzed. The first model proposed that negative beliefs about statistics have an effect mediated by avoidance behaviors towards statistics on a superficial work attitude. This model presented good goodness-of-fit indicators: $x^2_{(62)}$= 101.71, p = 0.001, *RMSEA* = 0.05 (0.03–0.06), *CFI* = 0.94 and *SRMR* = 0.05. Figure 5 shows the model tested.

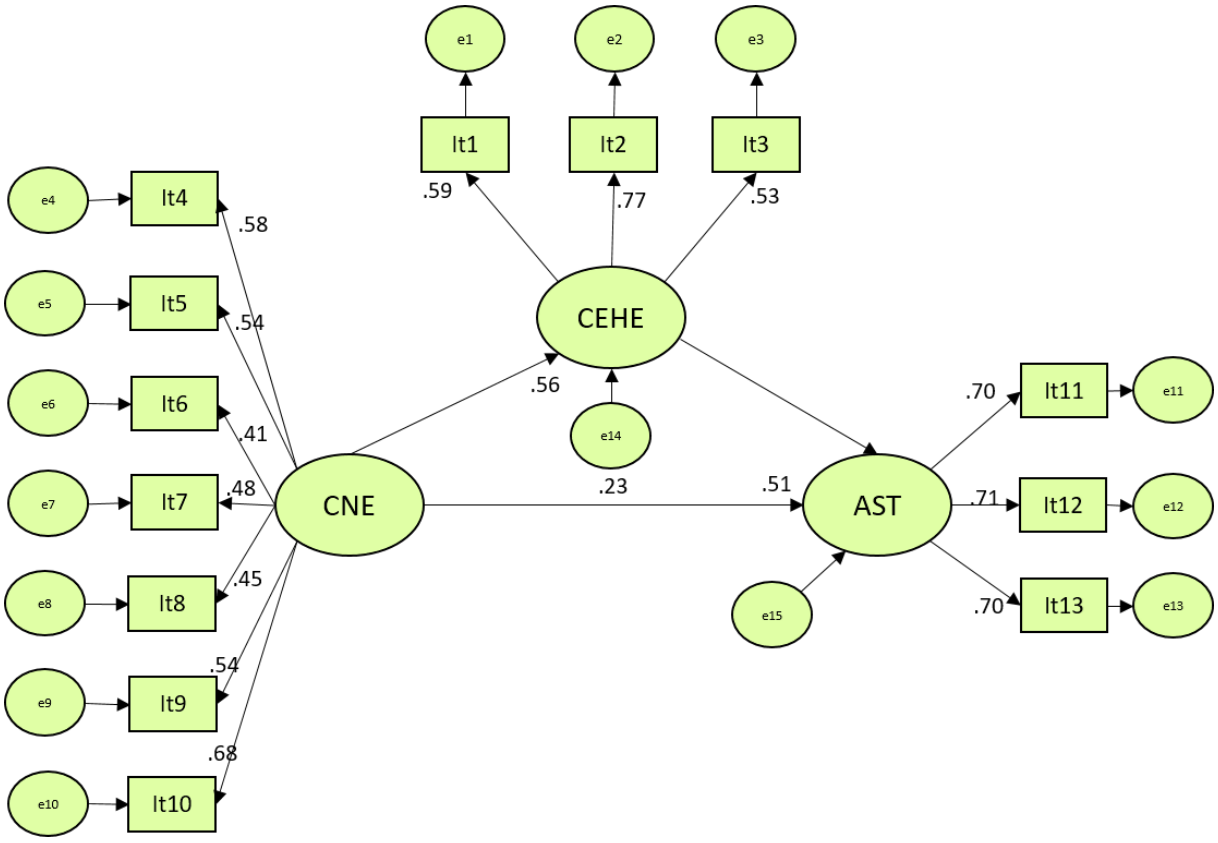

Figure 5. First Model Tested by the Structural Equation Process.

The second analyzed model arises as a nested model that is projected from the first proposed model, for which the direct effect of negative beliefs towards statistics was eliminated and its indirect mediating effect was analyzed through avoidance behaviors on the superficial attitude to work. Like the previous model, this model presented adequate goodness-of-fit parameters: $x^2_{(63)}$ = 106.29, p = 0.001, *RMSEA* = 0.05 (0.03–0.06), *CFI* = 0.93, and *SRMR* = 0.05. Figure 6 presents the second tested model.

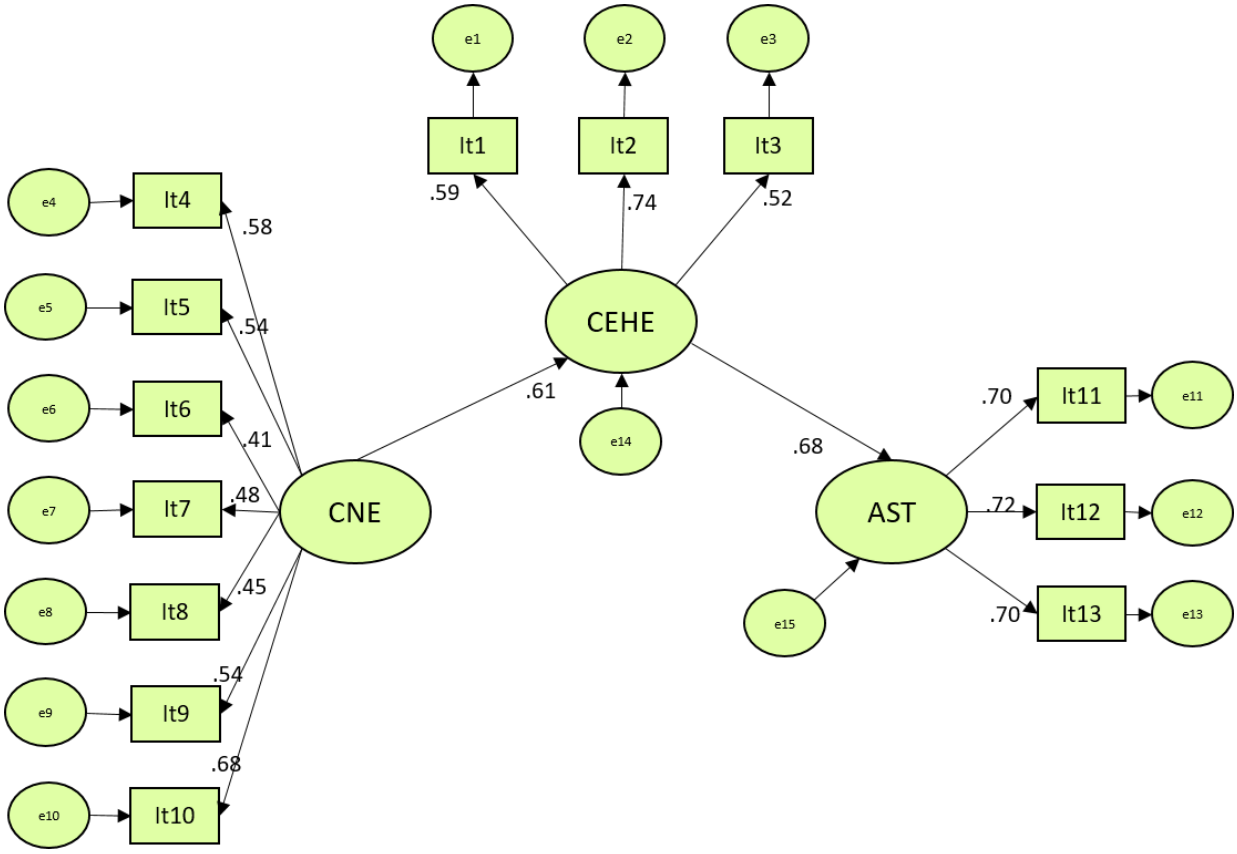

Figure 6. Second Model Tested by the Structural Equations Process

Subsequently, we proceeded to calculate whether there were significant differences between the two proposed models, finding differences between both models (Δx^2 = 4.58 with 1 degree of freedom, p = 0.03). Therefore, the first hypothesized model was accepted, which proposes that negative beliefs about statistics have a direct effect, mediated by avoidance behavior, on superficial work toward statistics.

4- Discussion

This article reports a research project that included two studies that sought to contribute to the line of research on learning statistics at the university level from a Latin American standpoint, a process that is still under development since there are several problems related to its execution, such as negative beliefs, fear, avoidance behavior, and superficial work attitudes.

The central contribution of this research project lies on several levels: a scale that measures important variables related to learning statistics and an explanatory model that proposes an interesting theory to understand the superficial attitude of Latin American students towards statistics, who, as we have pointed out, manage to pass the subject but do so with superficial performance levels and without achieving meaningful levels of learning. In relation to the analysis of the hypotheses proposed, the identification of three factors or constructs underlying the SABS scale, although it does not provide complete support for the first research hypothesis of the first study, provides more information for understanding the behavior of students in learning statistics. In addition, the 3-factor model presents the best percentage of explained variance, internal consistency, and factorial goodness-of-fit [21]. This provides evidence in favor of having a brief scale in Spanish with adequate psychometric properties, which was one of the objectives of the present study.

The results suggest that negative beliefs and fear of statistics are associated with and determine 42% of the variance of the avoidance behavior towards statistics in Latin American students. These results provide evidence in favor of the second research hypothesis. Moreover, these results suggest the development and execution of pedagogical projects in university careers, in which attitudes towards statistics, which are currently identified as of little or no use in university professional training, can be reconfigured [22].

As an important point based on the results, in the implementation of future innovative proposals to improve the pedagogical process of statistics, the dynamic use of technological resources and real data applied to everyday life (beyond the simulated learning of formulas) should be considered. Additionally, students should develop interpretative logic for statistics that would favor their active participation and the application of the concepts in certain projects associated with the most significant subjects of their careers [23, 24].

Furthermore, pedagogical changes to improve students' attitudes and beliefs about statistics and their anxiety, fear, and avoidance behavior towards their learning should be considered [3, 25]. This finding should be taken into consideration when creating the curricular contents of the subject so that the teacher provides a safe emotional environment in the classroom that is conducive to teaching statistics, in view of the fact that traditionally this subject is considered difficult, where there is a high percentage of students who fail and do not consider it to be of great benefit to their professional future [17, 26, 27].

On the other hand, in relation to the differences presented in the participants of the survey according to gender and age group, the data provided leans towards the third hypothesis raised in the first study, which was related to previous research [28–35]. Consequently, this problem should be addressed starting in the first semesters of the students' careers and corresponding gender. Similarly, these results provide evidence in favor of the fourth hypothesis, which generates a future challenge in the training of students [36–38]. The challenge is to contribute to the development of students' liking for statistics so that negative beliefs, fear, and avoidance behavior towards this subject decrease [39, 40].

The second study arises from the need to understand the dynamics surrounding the students' superficial attitudes towards learning statistics in greater depth. The proposed theoretical model generates empirical evidence in favor of the two hypotheses. First, negative beliefs towards statistics generated a statistically significant impact on the superficial attitudes of university students towards their learning. This finding confirms the need to make pedagogical changes in the teaching of the subject that will allow students to be interested in the proposed content [41]. Similarly, the authors consider this change or modification necessary since it will encourage students to build their knowledge and find it less bothersome to apply statistical procedures.

The second hypothesis proposes that avoidance behaviors towards statistics play a mediating role in the causal relationship between negative beliefs towards statistics and the superficial attitude towards learning them, for which significant empirical evidence was found in favor of this hypothesis. This finding makes it evident that the negative mental construct towards statistics will generate insignificant learning and, in turn, avoidance behaviors [42]. Therefore, the results of this study highlight the importance of working on beliefs about statistics. If this shift is achieved, we can generate an inverse relationship where we can have committed behaviors in favor of statistics and promote deep learning with meaningful knowledge of this subject [43].

The subjective component present in the self-report scale designed and applied was a limitation of the research. This limitation implies a bias in the perception of university students' behavior. However, the psychometric properties of the scale suggest that this bias had a minimal impact on the results.

As a guideline for future research and based on the results of this study, the need arises to carry out more research. A fruitful line of future work would be to delve deeper into students' subjective constructs of statistics. Moreover, another actor of great importance in learning statistics is the teacher, who should be the object of future research. Finally, within this promising line of research, it is of interest to analyze the impact of different strategies to modify university students' beliefs about statistics.

5- Conclusion

From a Latin American standpoint, it is essential to improve the teaching and learning processes of higher education. An area of vital importance to intervene in is statistics, since, as seen in this research, there is a significant number of university students who fear or reject this science. This attitude towards statistics has generated avoidance behavior or superficial performance in learning quantitative calculations. The findings found in this research elicit making the necessary changes in the way the subject of statistics is taught since it is key to the development of science in a country.

6- Declarations

6-1-Author Contributions

Conceptualization, C.R-G., V.R., and J.C.C.; methodology, C.R-G. and J.C.C.; formal analysis, C.R-G., V.R., and J.C.C.; investigation, C.R-G., and V.R.; writing—original draft preparation, C.R-G., V.R., and J.C.C.; writing—review and editing, C.R-G., V.R., and J.C.C.; project administration, C.R-G., V.R., and J.C.C. All authors have read and agreed to the published version of the manuscript.

6-2- Data Availability Statement

The data presented in this study are available on request from the corresponding author.

6-3- Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

6-4- Institutional Review Board Statement

This research was approved by the Comité de Ética para la Investigación con Seres Humanos (Ethics Committee for Research with Human Beings), Universidad Tecnológica Indoamérica.

6-5- Informed Consent Statement

All participants provided their written consent to participate in this study.

6-6- Conflicts of Interest

The authors declare that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

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