STUDENTS' ATTITUDES TOWARD STATISTICS: A COMPARISON BETWEEN UNIVERSITIES

Arturo GARCIA-SANTILLÁN
Universidad Cristóbal Colón
Veracruz, Ver., México
agarcias@ucc.mx

Milka E. ESCALERA-CHÁVEZ
Universidad Autónoma de San Luis Potosí
San Luis Potosí, SLP, México
milkaech@uaslp.mx

Carlos A. ROJAS-KRAMER
Universidad Cristóbal Colón
Veracruz, Ver., México
crk@ucc.mx

Arturo CÓRDOVA-RANGEL
Universidad Politécnica de Aguascalientes
Aguascalientes, Ags., México
arturo.cordova@upa.edu.mx

Felipe POZOS-TEXON
Instituto Tecnológico de Veracruz
Veracruz, Ver., México
fpozost@gmail.com

ABSTRACT
This research work aims to compare students' Attitudes toward Statistics (ATS) between undergraduates of various universities. The scale proposed by Wise (1985) was utilized to measure the ATS. Two dimensions integrate the scale: Attitudes toward Field (ATF) and Attitudes toward Course (ATC). The survey was conducted among 672 students enrolled in mathematics courses at three Mexican universities: Universidad Cristóbal Colón (UCC), Universidad Politécnica de Aguascalientes (UPA), and Unidad Académica Multidisciplinaria Zona Media of the Universidad Autónoma de San Luis Potosí (UASLP). The obtained data were processed by analysis of variance (ANOVA). The results show that students' ATC are equal for the three universities; however, evidence shows that students from UPA have the most positive ATF among them.

INTRODUCTION

The fundamental purpose of this research work is to compare students' Attitudes toward Statistics (ATS) among undergraduates of the three participating Mexican universities: Universidad Cristóbal Colón (UCC), Universidad Politécnica de Aguascalientes (UPA), and Unidad Académica Multidisciplinaria Zona Media of the Universidad Autónoma de San Luis Potosí (UASLP). The first one is a private university while the others are public ones.

The scale of ATS proposed by Wise (1985) was deployed as measuring instrument. The scale consists of 29 items and integrates two sub-scales: the Attitudes toward Field (ATF) sub-scale with 20 items and the Attitudes toward Course (ATC) sub-scale with nine items. Accordingly, the students' ATS is compared based on these sub-scales, and the main variable is also twofold: *students' attitudes toward the statistical field and the course of statistics.*

REVIEW OF LITERATURE

Recently, García-Santillán, Venegas-Martínez and Escalera-Chávez (2013) noted that the statistics courses are included in almost all college programs (degree and post-degree). It is a consequence of the significant role given to statistics in the scientific and technical training of several professions. As a result, thousands of undergraduate students, even those not mathematically oriented, continue taking statistics courses worldwide (Blanco, 2008). However, the absence of an achievement in this field by students of social science, behavioral science or education, among others, is a recurring topic that teachers and researchers have highlighted in a diverse cultural context for more than 30 years. Furthermore, in this kind of students frequently is observed: emotional reactions, negative attitudes and beliefs toward statistics, reduced interest in the area, and a limited quantitative training (see Blanco, 2004).

Student's attitude has a significant influence in teaching and learning process, and scholar performance (such as variable input and processing); this justified the need to study it. Furthermore, there is a relevant argument exposed by Auzmendi (1991), Gal and Ginsburg (1994) and Gal, Ginsburg and Schau (1997) about students' attitude toward statistics. They refer to an essential component of the background of students with which they can perform academic and professional activities after their university training (cited in Blanco 2008).

In other research (Mondéjar, Vargas and Bayot, 2008) developed another test founded on the methodological principles of ATS of Wise (1985) and the attitude scale toward statistics (EAE) of Auzmendi (1992). Their aim was to develop a test on the students' ATS and analyze the influence in the way they study. Mondéjar *et al.* (2008) described the psychometric properties of this new scale to measure attitude toward statistics; they obtained an effective tool to measure or quantify students' affective factors. The results may show the level of nervousness-anxiety and in what way other factors, such as gender and the university course selected, affect the study process.

All this could change the student's attitude. Phillips (1980) refers that students' attitude can suppose an obstacle or constituted an advantage for their learning. Other studies (Roberts and Saxe 1982; Beins 1985; Wise 1985; Katz and Tomezik 1988; Vanhoof, Castro, Onghena and Verschaffel 2006; Evans 2007) showed the relationship between ATS and academic outcomes or the professional use of this tool. In other studies, in Spain, Auzmendi (1992), Sánchez-López (1996) and Gil (1999) have confirmed the existence of a positive correlation between students' attitudes and their performance.

Other authors have attempted to measure the work underlying this issue. The ATS scale of Wise (1985), and the scale of Auzmendi (1992) approach such a measure by gathering the most pertinent characteristics of students regarding their attitude toward statistics, their difficulty with the mathematical component and their prejudice before the subject. From these studies, other works have derived such as Elmore and Lewis (1991) and Schau, Stevens, Dauphinee and Del Vecchio (1995). The ATS scale is composed of 29 items forming two scales, one that measures the affective relationship with learning and cognitive, and the second one that measures the perception of the student with the use of statistics. Mondéjar, Vargas and Bayot (2008) refer that the initial validation was based on a small sample, and subsequent studies (Mondéjar and Vargas, 2010; Woehlke, 1991) verified this structure. Regarding it, the work of Gil (1999) chooses to use a structure with five factors, one emotional factor, and four factors related to the cognitive component.

García-Santillán, Venegas, Escalera and Córdova (2013) found that one of the first operative definitions and measures of ATS is the test of Roberts and Bildderbach (1980) named *Statistics Attitudes Survey (SAS).* It is considered the first measure of a construct called *Attitude toward Statistics*, which was made for the purpose of providing a focused test in the statistical field, in order to measure this subject from the traditional and professional work of the students.

Blanco (2008) cited by García-Santillán, Escalera and Venegas (2013) carried out a critical review about students' ATS and describes some tests utilized to measure precisely the attitudes toward statistic in several kinds of students. That study refers to the research of Glencross and Cherian (1992) who cited the most significant research in the Anglo-Saxon context such as: *SAS* (Roberts and Bilderback, 1980; Robert and Saxe, 1982) which adds prior knowledge to the attitudinal components toward statistics, *ATS* (Wise, 1985), *Statistics Attitude Scale* (McCall, Madjini and Belli, 1991), *Statistics Attitude Inventory* (Zeidner, 1991), *Students' Attitudes toward Statistics* (Sutarso, 1992). Likewise, *Attitude toward Statistics* (Miller, Behrens, Green and Newman, 1993) which adds the dimensions value of statistics, aims of orientation and perceived ability, *Survey of Attitudes toward Statistics (SATS)* (Schau, Stevens, Dauphinee and Del Vecchio, 1995), and also the *Quantitative Attitudes Questionnaire* (Chang, 1996).

In another study, Estrada (2002) evaluated the attitudes of teachers and identified their relationship with personal variables like gender, previous training, specialty and the level of statistical knowledge. These results suggest that teachers have a positive attitude toward statistics. The attitude of men and women toward statistics is the same; there is no significant difference between them, and even there is no difference between students of different specialties. In contrast, various levels of statistics' previous knowledge are associated with distinct attitudes, so those who have never studied the subject have a more favorable average attitude toward it.

In other studies, Darías (2002) evaluated the ATS scale of Wise with a sample of 188 people (male and female) of the first courses in Psychology at the Universidad de la Laguna. The results obtained by principal component factor analysis and varimax rotation, show four factors that determine the attitude toward statistics, these being:

security, importance, usefulness, and wish to know. The safety factor is the one that provides more information, which allows to understand that anxiety is what determines ATS.

In the same way, Carmona (2002) evaluated ATS in psychology students, and his results show that there is no relationship between attitudes and performance; however, the study found that there are predictors, like students' math capacity, generating a better ATS. However, variables like age, gender, previous training, number of subjects taken, and grades earned in high school do not contribute to the attitude toward statistics. Moreover, Carmona (2004) conducted a systematic review of the research that provides empirical evidence about the reliability and validity of the test for measuring attitudes and anxiety toward statistics.

Muñoz (2002) evaluated students of Pedagogy, Psychology, Psychopedagogy and Social Work through a multiple regression analysis. Their findings show that attitudes are a better predictor of performance in the course, and self-efficacy, the perception of mathematical competence and the value that is given to statistics on the work, all this, could be the most significant predictors of the attitudes. These factors contribute to the total score of the scale with 65%.

Estrada, Batanero and Fortuny (2004) evaluated professors and demonstrated that ATS of future teachers, in general, is favorable. Their results show that the most contributing factor is the cognitive ability, i.e., professors believe that knowledge and skills are the most relevant variables to learn statistics, even when it is not an easy course. However, also note that when teachers are not clear about the usefulness of the statistics, the course is more challenging.

Regarding the variables that influence attitudes, the results of their studies show that the number of years of education has a statistically significant impact on the attitude, as it increases the knowledge of the subject. The ATS is more favorable because they see its usefulness in their development area, although it is always considered as difficult. However, with an emphasis on gender, there is a slight difference between men and women; women get more negative ATS than men. They also obtained significant differences depending on the specialty, because ATS vary as some specialties demand more analytical skills than others.

Vanhoof, Castro, Onghena and Verschaffel (2006) studied the relationship between attitudes toward statistics and tested results in the short and long term of university students who took statistics courses over five years in educational sciences. The attitude was evaluated with the ATS scale of Wise (1985) which includes two sub-scales: attitude toward the current course and attitude toward the field of study. The questionnaires were applied at the beginning and the end of college. Results show that during the first years (short term), students' attitudes were more favorable to the course, more than toward study area. However, in the long term when the students begin to write their thesis (fifth year) ATS are more favorable. According to the authors, it is because their early years the students may ignore the applications of the statistics' course. They also verified that students, who see the implementation of this subject in their field of study, appreciate its importance and make a better thesis work. Furthermore, they indicate that there is not a statistically significant relationship between attitudes and performance in the course.

In another study, Pierce (2006) applies the pre-test and post-test to 36 students from Ball University in three introductory courses: algebra, calculus, and statistics. In the pre-test, students in all courses were sure that they could learn, even if the course was tough; however, they perceived that interest and affection were not necessary for a better attitude toward the subject. Student's attitude in all courses was confident about their cognitive competence in mathematics and statistics. In the post-test, the differences shown in students were very small; however, 60% of the students gave more value to the statistics in the post-test.

Blanco (2008) provides a comprehensive and updated overview of the empirical research on the Spanish undergraduate students' ATS. For their part Baloğlu, Koçak & Zelhart (2007) investigated the relation between attitudes (toward the actual course and toward the field of study) and anxiety toward statistics (the value of the statistics, anxiety toward the course of statistics and examinations, the belief they have about computers, the fear to seek help, and fear of teachers) of 95 seniors and 55 undergraduate students in social sciences. Canonical-correlation analysis techniques were used to process the data. The results show that both had a negative attitude toward statistics, i.e. anxiety of seniors and undergraduate students toward statistics' courses and field of application.

Mondéjar, Vargas and Bayot (2008) applied a new test to measure students' ATS with four dimensions: Interest, anxiety, perceived usefulness for the professional career, and usefulness of statistics for their professional future. Their results showed how study habits affect students' ATS. When students adopt a more detailed way to study, they tend to consider the course more interesting. Moreover, they perceive usefulness for their professional future and have less anxiety about the subject. However, the ATS are not positive when the student takes a more superficial approach for studying because he has a lower level of interest and a slight increase in anxiety and perceives less usefulness in the course.

Shield and Shield (2008) applied a pre and post-test to 287 students from Augsburg College, in order to measure ATS in four dimensions: difficulty, affection, cognitive competence, and value. In the pre-test, they found that students show cognitive competence to learn statistics. Moreover, they do not believe that the subject is easy, and they value the subject regarding their usefulness in the personal and professional fields. However, they were impartial about whether they liked or not the statistics course. After students had completed a traditional course, they appreciated more the statistics as a tool, and they had a better attitude toward it.

When comparing the results of Schield and Schield (2008) study, with the results obtained by Pierce (2006), it is evident that there is very little difference between them because students of both institutions consider that even being it a complicated course they have the ability to learn.

In another study, Vanhoof (2010) found that the ATS is relatively stable, even over a longer period. These results are consistent with the Mc Leod (1992) description of attitude that indicates that attitudes are resistant to change, especially after high school, as Leong (2006) has demonstrated. Indeed, the results on the relative stability, which is presented, do not oppose the possibility that individual behavior changes over time. Furthermore, results show the sense of the relationship between attitudes toward statistics and performance on statistics.

In summary, the questionnaires most utilized to measure ATS are: SAS of Roberts and Bilderback (1980), the scale of ATS of Wise (1985) and the SATS Survey Attitudes Toward Statistics of Schau *et al.* (1995).

Regarding questionnaires which measure anxiety toward statistics, the most used are the STARS of Cruise, Cash and Bolton (1985), followed by the version of MARS of Suinn and Edwards (1982) and Suinn, Taylor and Edwards (1988) and developed by Plake and Parker (1982). The most important results about the psychometric properties of these questionnaires are:

a) The majority of the scales that comprise the analyzed questionnaires have shown high internal consistency and reliability.
b) Reliability evidence based on internal structure, domain structure of ATS has been conceived theoretically in a variety of ways: from a one-dimensional structure in the SAS of Roberts and Bilderback (1980) up to a composed of five dimensions in EAE of Auzmendi (1991). The same applies to the domain of anxiety toward statistics, with proposals, which range from the single dimension of SAS by Pretorius and Norman (1992), up to the six dimensions of STARS by Cruise *et al*, (1985).
c) In all cases, factor analysis techniques were used to study whether students' responses to the questionnaires were consistent with these different structures.
d) Regarding the evidence of content validity is noteworthy that, in several of the analyzed questionnaires, there was no evidence obtained. Only four questionnaires (STARS, ATS, QAQ, and SATS) were evaluated by expert judges. These assessments about item-dimension consistency were performed in the early stages of the development of the questionnaires and served primarily as a method for selection of items.
e) When the questionnaire scores have been used to predict the performance of students in the subjects of statistics, it has been found that both variables are weakly related. However, in those studies that have used more than one of the revised questionnaires has been found high convergence among them. With regard to the variables that allow predicting student´s attitudes or anxiety, both previous training in mathematics and statistics as the self-conception of capacities related to these subjects, have shown consistent relationships with scores on the questionnaires for attitudes or anxiety. Instead, when students' gender, their ages, or other personal characteristics are utilized to try to predict their attitudes, there is a comparative loss in precision.

This argument matches with that of Gal, Ginsburg, and Schau (1997) who asserted that one of the main research problems in this field is the lack of theoretical models to guide the works. The lack of academic background is reflected, for example, at one of the most important aspects of the development and validation of a measuring instrument, namely the determination of its internal structure. However, with every obtained result in different empirical studies which have been reported in the last two decades, it is possible to think that it has tried to reach theoretical models to explain the phenomenon of anxiety and attitude toward mathematics and statistics.
With the previous theoretical and empirical arguments, the research question, objective, and hypothesis are defined as follow.

Central question
Are there significant differences regarding ATS in undergraduates from UCC, UAP, and UASLP?

Objective
The primary purpose of this work is to compare students' ATS in order to determine whether there are differences regarding ATS in undergraduates from UCC, UAP, and UASLP. The ATS scale of Wise is the measuring instrument for this purpose.

Hypothesis
Under the assumption of Wise concerning ATS, the hypothesis are defined as follow:

H_1: There is a difference among students in the UCC, UAP, and UASLP, regarding their ATF.

H_2: There is a difference among students in the UCC, UAP, and UASLP, regarding their ATC.

RESEARCH METHODOLOGY
This study is non-experimental and cross-sectional. The sample was selected by the criterion of non-probability sampling, and it was formed by 672 students enrolled in mathematics courses at UCC, UAP, and UASLP, all of them in Mexico. The selection criteria were twofold: first, include students who have completed one field of statistics for the degree program they were studying, and second they were available at the University to answer the survey.

The instrument used was a survey of ATS of Wise (1985). The scales were applied in person to students in a variety of degree courses in several University careers (see tables 1, 2 and 3).

All groups of students took mathematics courses, specifically statistics courses, between second and third scholar year, combining ordinary classroom session and other practices in a computer laboratory.

Table 1. Population at UCC

Bachelor	Students
Management	49
Accounting	41
Economics	20
Marketing	35
International Markets and Business	83
Tourism Management	66
Total	294

Source: own

Table 2. Population at UASLP

Bachelor	Students
Management	73
Marketing	74
Accounting	67
Total	214

Souce: own

Table 3. Population at UPA

Undergraduate-Major	Students
Business and Administration	44
Industrial Engineering	30
Strategic Information Systems Engineering	30
Mechatronics Engineering	30
Mechanical Engineering	30
Total	164

Source: own

Appendix 1 shows the questionnaire utilized for ATS scale. This scale, proposed by Wise (1985), includes 29 items and has two sub-scales: The ATF sub-scale consists of the following 20 items, with reverse-keyed items indicated by an "(R)": 1, 3, 5, 6(R), 9, 10(R), 11, 13, 14(R), 16(R), 17, 19, 20(R), 21, 22, 23, 24, 26, 28(R), 29 and The ATC sub-scale consists of the following 9 items: 2(R), 4(R), 7(R), 8, 12(R), 15(R), 18(R), 25(R), 27(R). To score the ATS, only sum the appropriate item scores for the sub-scales and the total scale.

In order to prove the hypothesis and answer the research question, an *F* distribution statistical procedure was performed. The *F* distribution is the probability distribution associated with the *f* statistic. The *f* statistic, also known as *f* value is a random variable that has an F distribution.

The steps required for computing an *f* statistic:

- Select a random sample of size n_1 from a normal population, having a standard deviation equal to σ_1.
- Select an independent random sample of size n_2 from a normal population, having a standard deviation equal to σ_2.
- The *f* statistic is the ratio of s_1^2/σ_1^2 and s_2^2/σ_2^2.

The following equivalent equations are commonly used to compute an *f* statistic:

$$f = \left[S_1^2 / \sigma_1^2\right] / \left[S_2^2 / \sigma_2^2\right]$$
$$f = \left[S_1^2 * \sigma_1^2\right] / \left[S_2^2 * \sigma_2^2\right]$$
$$f = \left[X_1^2 / v_1\right] / \left[X_2^2 / v_2\right]$$
$$f = \left[X_1^2 * v_2\right] / \left[X_2^2 * v_1\right]$$

Where σ_1 is the standard deviation of population 1, s_1 is the standard deviation of the sample drawn from population 1, σ_2 is the standard deviation of population 2, S_2 is the standard deviation of the sample drawn from population 2, $X^2{}_1$ is the chi-square statistic for the sample drawn from population 1, v_1 is the degrees of freedom for $X^2{}_1$, $X^2{}_2$ is the chi-square statistic for the sample drawn from population 2, and v_2 is the degrees of freedom for $X^2{}_2$. Note that degrees of freedom $v_1 = n_1 - 1$, and degrees of freedom $v_2 = n_2 - 1$.

The distribution of all possible values of the *f* statistic is called an *F distribution*, with $v_1 = n_1 - 1$ and $v_2 = n_2 - 1$ degrees of freedom.

The curve of the F distribution depends on the degrees of freedom, v_1 and v_2. When describing an F distribution, the number of degrees of freedom associated with the standard deviation in the numerator of the *f* statistic is always stated first. The F distribution has the following properties:

- The mean of the distribution is equal to:

$$v_2 / \left(v_2 - 2\right) for v_2 > 2.$$

- The variance is equal to:

$$\left[2 * v_2^2 * \left(v_1 + v_1 - 2\right)\right] / \left[v_1 * \left(v_2 - 2\right)^2 * \left(v_2 - 4\right)\right] for v_2 > 4.$$

Intuitively, the variance of two populations σ_1^2 and σ_2^2 could be compared utilizing the ratio of the sample variances S_1^2 / S_2^2. If the result of S_1^2 / S_2^2 is close to 1, there is a little evidence to show that σ_1^2 and σ_2^2 are not equal. Moreover, a very large or very small value for S_1^2 / S_2^2 provides proof of a difference in the population's variances.

The resulting ratio of two random variables independent chi-square -each one divided into their corresponding degrees of freedom- is called the random variable *F*, and is given by:

$$F = \frac{U/v_1}{V/v_2}$$

Where: *U* and *V* are random variables independent chi-square with degrees of freedom v_1 and v_2 respectively. Then the distribution of the random variable is given by:

$$f(x) = \frac{\Gamma\left[\frac{(v_1+v_2)}{2}\right]\left(\frac{v_1}{v_2}\right)^{\frac{v_1}{2}} x^{\left(\frac{v_1}{2}\right)} - 1}{\Gamma\left(\frac{v_1}{2}\right)\Gamma\left(\frac{v_2}{2}\right)\left(1+\frac{v_1 x}{v_2}\right)^{\frac{(v_1+v_2)}{2}}}$$

$$0 < x < \infty$$

The *F* distribution with v_1 degrees of freedom in the numerator and v_2 degrees of freedom in the denominator. The mean and variance of the distribution *F* are given by:

$$\mu = v_2 / v_2 - 2$$
$$to\_v_2 > 2$$

$$\sigma^2 = \frac{2v_2^2(v_1+v_2-2)}{v_1(v_2-2)^2(v_2-4)}$$

$$to\_v_2 > 4$$

The random variable *F* is not negative, and the distribution has a bias to the right. The distribution *F* has a similar appearance to the chi-square distribution, however, it founded centered with respect to 1, and the two parameters v_1 and v_2 given an additional flexibility regarding the distribution *F*. If S_1^2 / S_2^2 are independent variances of size n_1 and n_2 taken from normal populations with variance σ_1^2 and σ_2^2, then:

$$F = \frac{S_1^2/\sigma_1^2}{S_2^2/\sigma_2^2} = \frac{S_1^2\sigma_2^2}{S_2^2\sigma_1^2} = \left(\frac{S_1}{S_2}\right)^2\left(\frac{\sigma_2}{\sigma_1}\right)^2$$

DATA ANALYSIS

First, it was carried out a reliability analysis of the data that was obtained as the result of applying the questionnaires personally among the student population, specifically being it the scale of Wise (1985). Therefore, a reliability test was performed using the Cronbach's alpha coefficient (α). This reliability coefficient can have values between 0 and 1, which verifies whether the information gathered is inadequate or defective and could lead to false conclusions otherwise be reliable and stable measurements that may be made. Cronbach's alpha (α) is a squared correlation coefficient, which measures the consistency of the items averaging all correlations among all questions (García-Santillán *et al.* 2013).

The closer it gets to 1, the better the reliability, considering that starting from 0.80 is a very acceptable value. Thus, the Cronbach's alpha can be set as a function of the number of items and the average of correlations among the items.

$$\partial = \frac{N * \bar{r}}{1 + (N-1) * \bar{r}}$$

Where: N = Number of items (or latent variables), $\bar{r}$ = average of correlations among the items.

The information collected from a population (672) of undergraduate students was processed. Results are shown in Table 4.

Table 4. Population's results

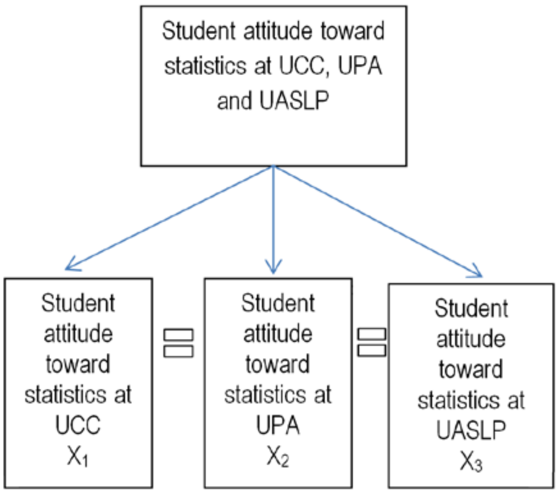
Cronbach's Alpha overall = 0.846				N of Items = 29	
ATF sub-scale				ATC sub-scale	
1	0.842	17	0.848	2	0.842
3	0.843	19	0.842	4	0.840
5	0.844	20	0.833	7	0.834
6	0.836	21	0.840	8	0.840
9	0.842	22	0.841	12	0.834
10	0.836	23	0.840	15	0.848
11	0.847	24	0.841	18	0.839
13	0.840	26	0.842	25	0.837
14	0.872	28	0.835	27	0.836
16	0.835	29	0.842		

Source: own

The result obtained from the total items is (0.846) and individual, grouped into two dimensions ATF and ATC, is more than 0.8. Both are very acceptable according to Hair, Anderson, Tatham and Black (1999) reference ($\alpha > 0.8$). Therefore, the instrument (the scale) have the characteristics of consistency and reliability that is required for the study, so the validity of the test is confirmed.

The hypothesis was redefined as hypothesis/causal and presented as a conceptual model depicted in Figure 1.

Figure 1. Conceptual Model



Source: own

The analysis of variance for one factor (ANOVA) was used to compare groups. The value of the *F* statistic reflects means similarities. In order to corroborate or refute the difference between groups, the critical value associated with the *F* statistic is compared, therefore, if the critical level associated is less than 0.05, then the hypothesis of equality of means should be rejected and may be concluded that compared population means are not all equal. The results are shown in Table 5.

Table 5. ANOVA test results

		Sum of square	df	Quadratic mean	F	Sig
Attitude toward field	Among groups	1245.051	2	622.525	9.524	0.000
	Into the groups	43729.198	669	65.365		
	Total	44974.249	671			
Attitude toward course	Among groups	7309.519	2	3654.759	122.990	0.000
	Into the groups	19879.944	669	29.716		
	Total	27189.463	671			

Source: own

The quotient between the two squares mean, Inter and Intra group of ATS, gave the value of *F* for each group. The obtained values were: ATF ($F = 9.524$, $p = 0.00$), ATC ($F = 122.990$, $p = 0.00$). To test the significance, the decision rule is the following: "if the value of "*p*" is greater than (α) means the null hypothesis (*Ho*) is accepted, and if also the values "p" obtained are less than 0.05, there is enough evidence to reject the null hypothesis, and it may be concluded that there are significant differences between students from different universities toward statistics.

The *F* statistic is used to verify the overall significance; hence the decision rule is: if the calculated *F* value is greater than the critical table value, the null hypothesis is rejected. Therefore, the conclusion is that population, composed of the students from the UPA, UCC, and UASLP, has significant differences with respect to ATS.

The Levene statistic perfectly illustrates the situation about the existence of differences between the variances of ATS. This fact is corroborated statistically, through the observation of significance. In this case, as the importance of the ATF is greater than 0.05, it was possible to affirm that the variance of variable's ATF is the same in the defined groups, whereas the significance of the ATC is less than 0.05, which indicates that the defined population at the three universities are not equal (Table 6).

Table 6. Test for the homogeneity of variances

	Levene statistic	df_1	df_2	Sig.
Attitude toward field	2.509	2	669	0.082
Attitude toward courses	13.153	2	669	0.000

Source: own

Tables 7, 8, 9 and 10 show values obtained from the *Post-hoc* methods that allow identifying precisely where differences are located.

Table 7. *Post-hoc* test of Attitude Toward Statistics (Field)

Dependent variable "field"	(I) UNI	(J) UNI	Means differences (I-J)	Standard error	Sig.
HSD Tukey	UCC	UASLP	-3.01456*	0.72648	0.000
		UPA	-2.25191*	0.78797	0.012
	UASLP	UCC	3.01456*	0.72648	0.000
		UPA	0.76265	0.83905	0.635
	UPA	UCC	2.25191*	0.78797	0.012
		UASLP	-0.76265	0.83905	0.635
Games-Howell	UCC	UASLP	-3.01456*	0.71960	0.000
		UPA	-2.25191*	0.79903	0.014
	UASLP	UCC	3.01456*	0.71960	0.000
		UPA	0.76265	0.84495	0.639
	UPA	UCC	2.25191*	0.79903	0.014
		UASLP	-0.76265	0.84495	0.639

Source: own

It is important to remember that, when there are low levels of significance (less than 0.05) the hypothesis which assumes that all groups have equal means is rejected; it makes necessary to identify which groups have these differences. To do this, the approximations to address this situation are used, these are: Not planned contrasts or *Post-hoc* contrasts. Furthermore, there are multiple conservative techniques since its purpose is to reduce the possibility of Type-I errors at the expense of increasing the likelihood of type II errors. Therefore, two *Post-hoc* methods were chosen; these being: Honestly Significant Difference of Tukey (HSD Tukey) and the Games-Howell method. The idea is to have a technique of multiple comparisons, and also, ranges too.

Results in Table 7 show ATS relative to the field when testing Tukey and Games-Howell are applied. The table shows that the number of significant differences (shown with an asterisk) detected by both methods, is the same (4). It is not possible to assume that the population variances are equal because the Levene test has a significance of 0.00 then, the proposed solution of Games-Howell method is followed, and it is observed that the group of UPA has a greater significance than 0.5 (. 639) indicating that there is no significant difference between the UPA and UASLP, then it follows that the UCC students have a different ATS regarding students UPA and UASLP.

In this sense, Table 8 shows the classification of the groups based on the degree of resemblance between the means. The table shows two subsets; the first includes the UCC and the second to UASLP and UPA. UCC's results (68.3639) indicate that the students' ATS are different from the students' attitudes at UASLP (71.3785) and the UPA (70.6159).

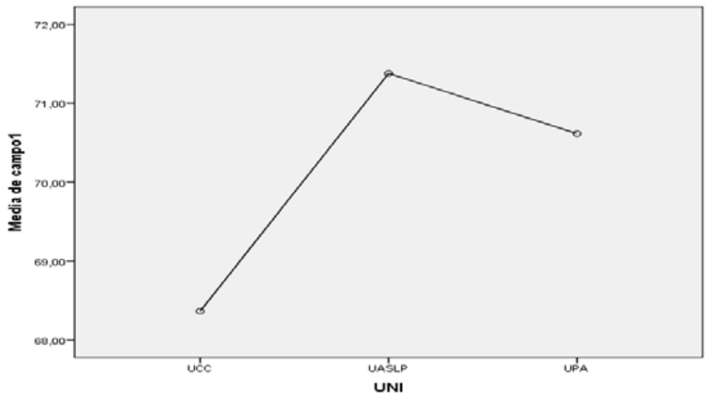
Concerning subset two, values of Table 8 show that there is a difference among UCC students regarding students from UASLP and UPA toward the statistical field; however, there is not a difference between students from UASLP and UPA. It is because differences between UASLP (71.3785) and UPA (70.6159) are not meaningful because the value of significance (0.596) is greater than 0.05.

Table 8. Homogeneous subset in relation to the field

	UNI	N	Subset for alpha = 0.05	
			1	2
HSD Tukey	UCC	294	68.3639	
	UPA	164		70.6159
	UASLP	214		71.3785
	Sig.		1.000	0.596

Source: own

Graphical representation of the homogeneous subset relative to the field is shown in graph 1.



Graph 1. Relationship between the mean of the ATF and Universities

Regarding the ATC, HSD of Tukey and Games_Howell methods applied to three groups of UCC, UPA and UASLP, show that the number of detected significant differences is the same with the two methods used. HSD of the Tukey method assumes that the population variances are equal, but it is not possible to assume that the variances are equal because the Levene test has a significance of 0.00, then, results obtained by the Games-Howell method are observed. Results (Table 9) show that the three groups are significant since their values are less than 0.05, i.e. there is a difference in the student attitude toward statistics about the course.

Table 9. *Post-hoc* test of ATC

Dependent variable "Course"	(I) UNI	(J) UNI	Means differences (I-J)	Standard error	Sig.
HSD Tukey	UCC	UASLP	-3.38372*	0.48983	0.000
		UPA	-8.31898*	0.53129	0.000
	UASLP	UCC	3.38372*	0.48983	0.000
		UPA	-4.93526*	0.56573	0.000
	UPA	UCC	8.31898*	0.53129	0.000
		UASLP	4.93526*	0.56573	0.000
Games-Howell	UCC	UASLP	-3.38372*	0.46563	0.000
		UPA	-8.31898*	0.55681	0.000
	UASLP	UCC	3.38372*	0.46563	0.000
		UPA	-4.93526*	0.52880	0.000
	UPA	UCC	8.31898*	0.55681	0.000
		UASLP	4.93526*	0.52880	0.000

Source: own

Table 10 shows the classification of the groups based on the degree, so similar, which exists between the means. Thus, in subset 1 are included UCC students, in the subset 2 UASLP students and finally in the subset 3 UPA students.

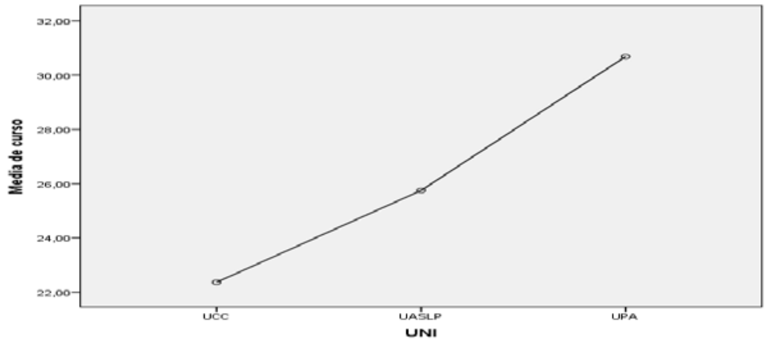
Table 10. Homogeneous subset in relation to the Course

	University	N	Subset for alpha = 0.05 1	2	3
HSD Tukey	UCC	294	22.3639		
	UASLP	214		25.7477	
	UPA	164			30.6829
	Sig.		1.000	1.000	1.000

Source: own

In each group, there is just one subset, indicating that every group is different, i.e. the ATC is different. UCC students have a more positive ATC (22.3639) than UASLP students (25.7477), and these even better than UPA students (30.6829).

Graphical representation of the homogeneous subset relative to the course is shown in graph 2.



Graph 2. Relationship between the mean of the ATC and Universities

DISCUSSION AND CONCLUSION

According to the results and the evidence obtained, it is clear that there is a significant difference in ATS among students of the three universities: UCC, UPA, andUASLP.

The evidence shows that there are differences in students' ATC of statistics in the three universities. However, regarding the students' ATF, evidence shows that UPA and UASLP students do not have significant differences; however, there is a discrepancy when confronted with UCC students.

Results are similar to those reported by Pierce (2006), who showed that ATS is not distinct among students from different institutions. However, the vast majority perceives the statistics' course as challenging, and, therefore, their attitude is not favorable for learning. In contrast, the outcomes obtained in this study do not match to those exposed by Vanhoof, Castro, Onghena and Verschaffel (2006) who mentioned that when students see the application of this subject in the professional field, it improves their perception about statistics and the importance given to this matter.

In the case of the universities under study, the differences in students' ATS arise from the UPA focusing on practical applications of subjects, whereas the UCC and UASLP are rather centered on giving the students more theoretical support.

FURTHER RESEARCH

It is recommended, as a further research work, to replicate this study on different educational institutions around the world, with the purpose of identifying possible differences in the field.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX

1. Attitudes toward statistics

(Wise 1985) original test

Directions: For each of the following statements mark the rating category that most indicates how you currently feel about the statement. Please respond to all of the items.

Degree:_______________________ Male_____ Female____

ITEM	Strongly disagree	Disagree	neutral	agree	Strongly agree	Final code
1.-I feel that statistics will be useful to me in my profession.						
2. - The thought of being enrolled in a statistics course makes me nervous.						
3.- A good researcher must have training in statistics.						
4.- Statistics seems very mysterious to me.						
5.- Most people would benefit from taking a statistics course.						
6.- I have difficulty seeing how statistics relates to my field of study.						
7.- I being enrolled in a statistics course as a very unpleasant experience.						
8.- I would like to continue my statistical training in an advanced course.						

9.- Statistics will be useful to me in comparing the relative merits of different objects, methods, programs, etc.						
10.- Statistics is not really very useful because it tells us what we already know anyway.						
11.- Statistical training is relevant to my performance in my field of study.						
12.- I wish that I could have avoided taking my statistics course.						
13.- Statistics is a worthwhile part of my professional training.						
14.- Statistics is too math oriented to be of much use to me in the future.						
15.- I get upset at the thought of enrolling in another statistics course.						
16.- Statistical analysis is best left to the "experts" and should not be part of a						
17.- Statistics is an inseparable aspect of scientific research.						
18.- I feel intimidated when I have to deal with mathematical formulas.						
19.- I am excited at the prospect of actually using statistics in my job.						
20.- Studying statistics is a waste of time.						
21.- My statistical training will help me better understand the research being done in my field of study.						
22.- One becomes a more effective “consumer" of research findings if one has some training in statistics.						
23.- Training in statistics makes for a more well-rounded professional experience.						
24.- Statistical thinking can play a useful role in everyday life.						
25.- Dealing with numbers makes me uneasy.						
26.- I feel that statistics should be required early in one’s professional training.						
27.- Statistics is too complicated for me to use effectively.						
28.- Statistical training is not really useful for most professionals.						
29.- Statistical thinking will one day be as necessary for efficient citizenship as the ability to read and write.						

