AN EXPLORATORY FACTORIAL ANALYSIS TO MEASURE ATTITUDE TOWARD STATISTIC
(EMPIRICAL STUDY IN UNDERGRADUATE STUDENTS)

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ABSTRACT
This study aims to measure student's attitude towards statistics through a model that considers the variables proposed by Auzmendi (1992). Was examined whether the constructs: usefulness, motivation, liking, confidence and anxiety have influence in the student's attitude towards statistics. Were surveyed 298 students at the Cristóbal Colón University using the questionnaire proposed by Auzmendi. Data analysis was performed by factorial analysis with an extracted principal component. The results obtained from the Bartlett test of Sphericity KMO (.648), Chi square X^2 379.674 df 10, Sig. 0.00 < p 0.01, the value of each variable MSA (LIK .628; ANX .602; CNF .731; MTV .610 and USF .649 are within the acceptable value >0.50) All this provide evidence to reject Ho. Finally we obtained two factors: first one composed of three elements: usefulness, confidence, liking and other incorporates two elements: anxiety and motivation. The values of this last factor indicate if the student anxiety increased, decreased motivation and their explanatory power for each factor are expressed by their Eigenvalue 2.351 and 1.198 (with % variance 47.016 and 23.964 respectively, Total variance 71.08%)

Keywords: *Components, usefulness, motivation, likeness, confidence and anxiety.*
Mathematics Subject Classification: 97K80.

1. INTRODUCTION

1.1. Attitude towards Statistic

Almost all university studies (degree and posdegree) Statistics courses are present in the *curricula* of the university studies, all this fruit of the important role given to statistic, in the scientific and technical training of several and varied professionals profile. As a result, thousands of students in degrees and other specialties not mathematically oriented, continue taken statistics courses worldwide, all this like say Blanco [2]. However, the lack of an achievement in this area by the students' of Social Science, Behavioral Science or Education, among others, they`re recurring topic that teachers and researchers have been highlighting in diverse cultural context for at least three decades. Also in many repetitions have been reported: emotional reactions, attitudes and negative beliefs towards statistics students with little interest in the area and a limited quantitative training according to Elmore and Lewis [3]; Blanco [4]; Evans [5].

Into the educational research, statistical level has justified the need to pay attention to students' attitude mainly because they have an important influence on the process of teaching and learning and the same way, the immediate academic performance (such as variable input and process). Also important argument exposed by Auzmendi [1], Gal & Ginsburg [6], Gal, Ginsburg & Schau [7] and García-Santillán *et al*, [8] about students' attitude statistic; they refer to as an essential component of the background of student with which, after its university training, may carry out academic and professional activities. In the same way Baloglu [9] made a study in order to compare, the mathematics anxiety and statistics anxiety in relation to general anxiety. Other research by Mondejar, Vargas and Bayot [10] developed a test based on the methodological principles of Wise [11] attitude toward statistic (ATS) and scale attitude toward statistics (SATS) of Auzmendi [1]. The objectives were to develop a test on students 'attitude statistic and his analyze on influence in the form to study.

Mondéjar et al [10] describe the psychometric properties of this new scale to measuring attitude toward statistics; they obtained with the result a good tool to measuring or quantifying the students´ affective factors. The result may show the level of nervousness-anxiety and other factors such a gender and the university course studied affect the study process.

All this could affect students´ attitude like say Phillips [12], he refers to, that the students' attitude can suppose an obstacle or constituted and advantages for their learning. Other studies of Roberts and Saxe [13]; Beins [14]; Wise [11]; Katz and Tomezik [15]; Vanhoof et al [16]; Evans [5], showed the relationship between attitude toward

statistic and academic outcomes or the professional use of this tool. They have confirmed the existence of positive correlation between students' attitudes and their performance in this area. In other studies in Spain, Auzmendi [1], Sánchez-López [17] and Gil [18] have confirmed the existence of positive correlation between students 'attitudes and their performance.
Other studies have attempted to measure the work underlying this issue: e.g. scale ATS of Wise [11] and the scale SATS of Auzmendi [1] collected the most relevant characteristics of the students regarding their attitude towards statistics, his difficulty with the mathematical component and prejudice before the subject. Of this, have derivate works such as Elmore and Lewis [3] and Schau *et al* [19]. Similar studies are: Shultz and Koshino [20] who's obtained evidence of reliability and validity for Wise´s Attitude toward Statistics scale and Sorge and Schau [21] who measured the impact of engineering students' attitudes on achievement in statistics.
The scale ATS is structured of 29 items grouped in two scales, one that measures the affective relationship with learning and cognitive measures the perception of the student with the use of statistics. Mondéjar *et al* [10] refer to that initially validation was based on a sample very small, and was with subsequent studies such as Mondejar *et al* [10] or Woehlke [22] who´s corroborated this structure, and the work of Gil (1999) choose to use an structure with five factors: one of the emotional factor and the remaining four factors related cognitive component.

1.2. Statistics Attitude in Anglo-Saxon context.
One of the first operative definition and measure about attitude toward statistics is the test of Roberts and Bildderback [23] denominated *Statistics Attitudes Survey (SAS).* It's considered the first measure about construct called "Attitude toward statistics" in fact, was made with the intention of providing a focused test in statistics field in order to measure this subject, from the tradition and professional work of students.
In the review of literature about this subject, Blanco [2] it carried out a critical review on research on students' attitude toward statistics and describe, some inventories test that measure specifically the students' attitude statistic. In his study refer the research of Glencross & Cherian [24] who cited the most important studies in the Anglo-Saxon context such as: *Statistics Attitudes Survey- SAS* Roberts & Bilderback [23], Roberts & Reese, [25], *Attitudes toward Statistics- ATS* Wise [11], *Statistics Attitude Scale* McCall, Belli & Madjini [26], *Statistics Attitude Inventory* Zeidner [27], *Students´Attitudes Toward Statistics* Sutarso [28], *Attitude Toward Statistics* Miller, Behrens, Green and Newman [29], *Survey of Attitudes Toward Statistics –SATS* Schau, Stevens, Dauphinee and Del Vecchio [19], *Quantitative Attitudes Questionnaire* Chang [30] among other.

With the above, and considering that this study seeks to find answers to the research question about attitude towards statistic in undergraduate students, we use the scale proposed by Auzmendi. Therefore, it set the following:

1.3. Question, objective and hypothesis
1.3.1. Research question
RQ_1. Which the attitude toward statistic in undergraduate students?
1.3.2. Objectives:
O_1. Identify the factors that explain the attitude towards statistics
1.3.3. Hypotheses:
Hi_1: Liking is the factor that most explained the student's attitude towards statistic
Hi_2: Anxiety is the factor that most explained the student's attitude towards statistic
Hi_3: Confidence is the factor that most explained the student's attitude towards statistic
Hi_4: Motivation is the factor that most explained the student's attitude towards statistic
Hi_5: Usefulness is the factor that most explained the student's attitude towards statistic

2. MATERIALS AND METHODS
2.1. Design methodology and Kind study:
This study is non experimental, transeccional-descriptive, because we need to know the attitude toward statistics in undergraduate students at Cristobal Colon University.

2.2. Population and test
The sample was selected for the trial of non-probability sampling. Were surveyed 298 students at Cristóbal Colón University from several profiles, as; economy, management, accounting, marketing and tourism business management. The selection criteria were to include students who have completed at least one field of statistics in the degree program they were studying and were available at the institution to implement the survey. The instrument used was a survey of attitudes toward statistics or SATS of Auzmendi [1].

The scale proposed by Auzmendi indicates the existence of five factors: usefulness, anxiety, confidence, liking and motivation. The usefulness factor indicators are: Item 1, 6, 11, 16, 21; anxiety factor indicators are: Item 2, 7, 12, 17, 22; the confidence factor are: items 3, 8, 13, 18, 23; liking factor indicators are: Item 4, 9, 14, 19, 24. Finally indicators belonging to motivational factor are: items 5, 10, 15, 20, 25. The table 1 described the indicators, definitions and codes/items.

Table 1. Scale factors attitude toward statistics.

Indicators	Definition	Code/items
Liking	Refers to the liking of working with statistics.	LIK 4,9,14,19 and 24
Anxiety	Can be understood as the fear the students manifests towards statistics.	ANX 2,7,12,17 and 22
Confidence	Can be interpreted as the feeling of confidence of the skill in statistics.	CNF 3,8,13,18 and 23
Motivation	What the student feels towards the studying and usefulness of statistics.	MTV 5,10,15,20 and 25
Usefulness	It is related to the value that a student's gives statistics for its professional future.	USF 1,6,11,16 and 21

Source: take from García *et al* [8]

2.3. Statistical procedure

In this study, we used the principal components method to determine the number of indicators that make up each of the factors and select those with a factor loading greater than .70 Table 1 shows the indicators and their corresponding factors.

In order to measure; $X_1 X_2 \ldots\ldots X_{298}$ observed random variables, which are defined in the same population that share, m ($m<p$) commons causes to find $m+p$ new variables, which we call common factors ($Z_1, Z_2, \ldots Z_m$), besides, unique factors ($\varepsilon_1\ \varepsilon_2 \ldots\ldots \varepsilon_p$) in order to determine their contribution in the original variables ($X_1\ X_2 \ldots\ldots X_{p-1}\ X_p$) the model is now defined by the following equations according to Carrasco-Arroyo [31]:

$$\left| \begin{array}{l} X_1 = a_{11}Z_1 + a_{12}Z_2 + \ldots\ldots\ldots a_{1m}Z_m + b_1\xi_1 \\ X_2 = a_{21}Z_1 + a_{22}Z_2 + \ldots\ldots\ldots a_{2m}Z_m + b_2\xi_2 \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ X_p = a_{p1}Z_1 + a_{p2}Z_2 + \ldots\ldots\ldots a_{pm}Z_m + b_p\xi_p \end{array} \right| \quad (1)$$

Where:

$Z_1, Z_2, \ldots Z_m$ are common factors

$\varepsilon_1\ \varepsilon_2 \ldots\ldots \varepsilon_p$ are unique factors

Thus, $\varepsilon_1\ \varepsilon_2 \ldots\ldots \varepsilon_p$ have influence in all variables X_i (i=1 ………p) ξ_i influence in $X_i (i=1\ldots\ldots p)$

Model equations can be expressed in matrix form as follow:

$$\begin{vmatrix} X_1 = \\ X_2 = \\ \cdots\cdots \\ X_p = \end{vmatrix} = \begin{vmatrix} a_{11}a_{12}\ldots\ldots\ldots a_{1m} \\ a_{21}a_{22}\ldots\ldots\ldots a_{2m} \\ \ldots\ldots\ldots\ldots\ldots\ldots \\ a_{p1}a_{p2}\ldots\ldots\ldots a_{pm} \end{vmatrix} . \begin{vmatrix} Z_1 \\ Z_2 \\ \cdots \\ Z_1 \end{vmatrix} + \begin{vmatrix} b_1\xi_1 \\ b_2\xi_2 \\ \cdots\cdots \\ b_p\xi_p \end{vmatrix} \tag{2}$$

Therefore, the resulting model can be expressed in a condensed form as:

$$X = AZ + \xi_i \tag{3}$$

Where, we assume that $m<p$ because they want to explain the variables through a small number of new random variables and all of the (m + p) factors are correlated variables, that is, that the variability explained by a variable factor, have not relation with the other factors.
We know that the each observed variable of model is a result of lineal combination of each common factor with different weights (a_{ia}), those weights are called saturations, but one of part of x_i is not explained for common factors.
As we know, all problems intuitive can be inconsistent when obtaining solutions and therefore, we require the approach of hypothesis; hence, in the factor model we used the following assumptions:

$H_{1:}$ The factors are typified random variables, and inter correlated, like:

$$E\left[Z_i\right]=0 \quad E\left[\xi_i\right]=0 \quad E\left[Z_iZ_i\right]=1$$
$$E\left[\xi_i\xi_i\right]=1 \quad E\left[Z_iZ_{i'}\right]=0 \quad E\left[\xi_i\xi_{i'}\right]=0$$
$$E\left[Z_i\xi_i\right]=0$$

Further, we must consider that the factors have a primary goal to study and simplify the correlations between variables, measures, through the correlation matrix, then, we will understand that:

$H_{2:}$ The original variables could be typified by transforming these variables of type

$$x_i = \frac{x_i - \bar{x}}{\sigma_x} \tag{4}$$

Therefore, and considering the variance property we have:

$$\mathrm{var}(x_i) = a_{i1}^2\mathrm{var}(z_1) + a_{i2}^2\mathrm{var}(z_2) + \ldots\ldots\ldots\ldots\ldots a_{im}^2\mathrm{var}(z_m) + b_i^2\mathrm{var}(\xi_i) \tag{5}$$

Resulting: $$1 = a_{i1}^2 + a_{i2}^2 + a_{i3}^2 + \ldots.. + \ldots\ldots\ldots a_{im}^2 + b_i^2 \rightarrow \forall_i = 1\ldots\ldots\ldots\ldots p \tag{6}$$

2.3.1. Saturations, communalities and uniqueness

2.3.1.1. We denominated *saturations* of the variable x_i in the factor z_a of coefficient a_{ia}
In order to inform the relationship between the variables and the common factors is necessary determining the coefficient de **A** (assuming the hypotheses $\mathbf{H_1}$ y $\mathbf{H_2}$), where **V** is the matrix of eigenvectors and **Λ** matrix eigenvalues, so we obtained:

$$A = \begin{bmatrix} a_{11}a_{12}a_{13}..........a_{1m} \\ a_{21}a_{22}a_{23}..........a_{2m} \\ a_{31}a_{32}a_{33}..........a_{3m} \\ .... \\ a_{p1}a_{p2}a_{p3}..........a_{pm} \end{bmatrix} \tag{7}$$

$$\begin{aligned} R &= V\Lambda V' = V\Lambda^{1/2}\Lambda^{1/2}V' = AA' \\ A &= V\Lambda^{1/2} \end{aligned} \tag{8}$$

The above suggests that a_{ia} coincides with the correlation coefficient between the variables and factors. In the other sense, for the case of non-standardized variables, *A* is obtained from the covariance matrix *S*, hence the correlation between x_i and z_a is the ratio:

$$corr(i,a) = \frac{a_{ia}}{\sigma_a} = \frac{a_{ia}}{\sqrt{\lambda_a}} \tag{9}$$

Thus, the variance of the a_i factor is results of the sum of squares of saturations of a_i column of A:

$$\lambda_a = \sum_{i=1}^{p} a_{ia}^2 \tag{10}$$

Considering that:

$$A'A = (V\Lambda^{1/2})'(V\Lambda^{1/2}) = \Lambda^{1/2}V'V\Lambda^{1/2} = \Lambda^{1/2}I\Lambda^{1/2} = \Lambda \tag{11}$$

2.3.1.2. We denominated *communalities* to the next theorem:

$$h_i^2 = \sum_{a=1}^{m} a_{ia}^2 \tag{12}$$

The communalities show a percentage of variance of each variable (i) that explains for *m* factors.

Thus, every coefficient h_i^2 is called variable specificity. Therefore the matrix model **X=AZ+ξ,ξ** (unique factors matrix), **Z** (common factors matrix) will be lower while greater be the variation explain for every *m* (common factor).

So, if we work with typified variables and considering the variance property, so, we have:

$$\begin{aligned} 1 &= a_{i1}^2 + a_{i2}^2 + ... + a_{ia}^2 + b_2^2 \\ 1 &= h_i^2 + b_i^2 \end{aligned} \tag{13}$$

Recall that the variance of any variable, is the result of adding their communalities and the uniqueness b_i^2, thus, the number of factors obtained, there is a part of the variability of the original variables unexplained and correspond to a residue (unique factor).

2.3.2. Reduced correlation matrix
Based on correlation between variables i and i' we have now:

$$\mathrm{corr}(x_i x_{i'}) = \frac{\mathrm{cov}(x_i x_{i'})}{\sigma_i \sigma_{i'}} \tag{14}$$

Also, we know

$$x_i = \sum_{a=1}^{m} a_{ia} z_a + b_i \varepsilon_i \quad , \quad x_{i'} = \sum_{a=1}^{m} a_{i'a} z_a + b_{i'} \varepsilon_{i'} \tag{15}$$

The hypothesis which we started, now we have:

$$\mathrm{corr}(x_i x_{i'}) = \mathrm{cov}(x_i x_{i'}) = \sigma_{ii'} = E\left[\left(\sum_{a=1}^{m} a_{ia} z_a + b_i \varepsilon_i\right)\left(\sum_{a=1}^{m} a_{i'a} z_a + b_{i'} \varepsilon_{i'}\right)\right] \tag{16}$$

Developing the product:

$$= E\left[\sum_{a=1}^{m} a_{ia} a_{i'a} z_a z_a + \sum_{a=1}^{m} a_{ia} b_{i'} z_a \varepsilon_{i'} + \sum_{a=1}^{m} b_i a_{i'i} \varepsilon_i z_a + \sum_{a=1}^{m} b_i b_{i'} \varepsilon_i \varepsilon_{i'}\right] \tag{17}$$

From the linearity of hope and considering that the factors are uncorrelated (hypotheses of starting), now we have:

$$\mathrm{cov}(x_i x_{i'}) = \sigma_{ii'} = \sum_{a=1}^{m} a_{ia} a_{i'a} = \mathrm{corr}(x_i x_{i'}) \qquad \forall i, i' \to 1 \ldots\ldots\ldots\ldots p \tag{18}$$

The variance of variable *i*-esim is given for:

$$\mathrm{var}(x_i) = \sigma_i^2 = E\left[x_i x_i\right] = 1 = E\left[\sum_{a=1}^{m} (a_{ia} z_a + b_i \varepsilon_i)^2\right] =$$

$$= E\left[\sum_{a=1}^{m} (a_{ia}^2 z_a^2 + b_i^2 \varepsilon_i^2 + 2 a_{ia} b_i z_a \varepsilon_a)\right] \tag{19}$$

If we take again the start hypothesis, we can prove the follow expression:

$$\sigma_i^2 = 1 = \sum_{a=1}^{m} a_{ia}^2 + b_i^2 = h_i^2 + b_i^2 \tag{20}$$

In this way, we can test how the variance is divided into two parts: the communality and uniqueness, which is the residual variance not explained by the model

Therefore, we can say that the matrix form is: **R=AA'+ξ** where $\mathbf{R^* = R - \xi^2}$.

R^* is a reproduced correlation matrix, obtained from the matrix R

$$R^{*} = \begin{bmatrix} h_1^2 r_{12} r_{13} r_{14} \ldots\ldots r_{1p} \\ r_{21} h_2^2 r_{23} r_{24} \ldots\ldots r_{2p} \\ r_{31} r_{32} h_3^2 r_{34} \ldots\ldots r_{3p} \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ r_{p1} r_{p2} r_{p3} r_{p4} \ldots h_p^2 \end{bmatrix} \tag{21}$$

The fundamental identity is equivalent to the following expression: R^* AA'. Therefore the sample correlation matrix is a matrix estimator AA'. Meanwhile, a_{ia} saturation coefficients of variables in the factors, should verify this condition, which certainly, is not enough to determine them. When the product is estimated AA', we diagonalizable the reduced correlation matrix, whereas a solution of the equation would be: $R-\xi^2 = R^* = AA'$ is the matrix A, whose columns are the standardized eigenvectors of R^*. From this reduced matrix, through a diagonal, as mathematical instrument, we obtain through vectors and eigenvalues, the factor axes.

2.3.3. Factorial analysis viability

To validate the appropriateness of factorial model is necessary to design the sample correlation matrix R, from the data obtained. Also be performed prior hypothesis tests to determine the relevance of the factor model, that is, whether it is appropriate to analyze the data with this model.

A contrast to be performed is the Bartlett Test of Sphericity. It seeks to determine whether there is a relationship structure –relationships-- or not among the original variables. The correlation matrix *R* indicates the relationship between each pair of variables (r_{ij}) and its diagonal will be compose for 1(ones). Hence, if there is not relationship between the variables *h*, then, all correlation coefficients between each pair of variable would be zero. Therefore, the population correlation matrix coincides with the identity matrix and determinant will be equal to 1.

$$H_o : |R| = 1$$
$$H_1 : |R| \neq 1$$

If the data are a random sample from a multivariate normal distribution, then, under the null hypothesis, the determinant of the matrix is 1 and is shown as follows:

$$-\left[n-1-\frac{(2p+5)}{6} \right] \ln |R| \tag{22}$$

Under the null hypothesis, this statistic is asymptotically distributed through a X^2 distribution with $p(p-1)/2$ degrees freedom. So, in case of accepting the null hypothesis would not be advisable to perform factor analysis.

Another index is, the contrast of Kaiser-Meyer-Olkin, which is to compare the correlation coefficients and partial correlation coefficients. This measure is called sampling adequacy (KMO) and can be calculated for the whole or for each variable (MSA)

$$KMO = \frac{\sum_{j \neq i} \sum_{i \neq j} r_{ij}^2}{\sum_{j \neq i} \sum_{i \neq j} r_{ij}^2 + \sum_{j \neq i} \sum_{i \neq j} r_{ij(p)}^2} \qquad MSA = \frac{\sum_{i^1 j} r_{ij}^2}{\sum_{i^1 j} r_{ij}^2 + \sum_{i^1 j} r_{ij(p)}^2} ; i = 1, \ldots.., p \tag{23}$$

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

The statistical procedure to measure data is an exploratory Factorial Analyze Model; therefore it was taken the procedure proposed by García-Santillán *et al* (2012) and obtains the following matrix:

Students	*Variables* $X_1\ X_2 \ldots\ldots X_p$
1	$X_{11}\ X_{12} \ldots\ x_{1p}$
2	$X_{21}\ X_{22} \ldots\ x_{2p}$
…..	………
298	$X_{n1}\ X_{n2} \ldots\ x_{np}$

In order to measure the data collected from students and test the hypothesis (H_i) about a set of variables that form the construct for understanding the perception of students towards statistics, we considered the follow Hypothesis: Ho: ρ=0 have no corelation Ha: ρ ≠ 0 have correlation.

Statistic test to prove: χ^2, y Bartlett's test of sphericity, KMO (Kaiser-Meyer-Olkin), MSA (Measure of Sampling Adecuacy), significancy level: α =0.05; *p <0.05 load factorial of .70* Critic value: χ^2 calculated > χ^2 tables, then reject *Ho* and the decision rule is: Reject *Ho* if χ^2 calculated > χ^2 tables.

The above is given by the following equation:

$$
\begin{aligned}
X_1 &= a_{11}F_1 + a_{12}F_2 + \ldots\ldots + a_{1k}F_k + u_1 \\
X_2 &= a_{21}F_1 + a_{22}F_2 + \ldots\ldots + a_{2k}F_k + u_2 \\
&\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\
X_p &= a_{p1}F_1 + a_{p2}F_2 + \ldots\ldots + a_{pk}F_k + u_p
\end{aligned}
\tag{24}
$$

Where $F_1 \ldots F_k$ ($K \ll p$) are common factors, $u_1, \ldots u_p$ are specific factors and the coefficients $\{a_{ij}; i=1,\ldots,p; j=1,\ldots,k\}$ are the factorial load. It is assumed that the common factors have been standardized or normalized $E(F_i) = 0$, $Var(f_i) = 1$, the specific factors have a mean equal to zero and both factors have correlation $Cov(F_i,u_j) = 0$, $\forall_i = 1,\ldots,k$; j=1,….,p. With the following consideration: if the factors are correlated ($Cov(F_i, F_j) = 0$, if i≠j; j, i=1,…..,k) then we are dealing with a model with orthogonal factors, if not correlated, it is a model with oblique factors.

Therefore, the equation can be expressed as follows:

$$x = Af + u \ \hat{U}\ X = FA' + U \tag{25}$$

Where:

Data matrix	*Factorial load matrix*	*Factorial matrix*
$x = \begin{pmatrix} x_1 \\ x_2 \\ \ldots \\ x_p \end{pmatrix}, f = \begin{pmatrix} F_1 \\ F_2 \\ \ldots \\ F_k \end{pmatrix}, u = \begin{pmatrix} u_1 \\ u_2 \\ \ldots \\ u_p \end{pmatrix}$	$A = \begin{pmatrix} a_{11}a_{12}\ldots a_{ik} \\ a_{21}a_{22}\ldots a_{2k} \\ \ldots\ldots\ldots \\ a_{p1}a_{p2}\ldots a_{pk} \end{pmatrix}$	$F = \begin{pmatrix} f_{11}f_{12}\ldots f_{ik} \\ f_{21}f_{22}\ldots f_{2k} \\ \ldots\ldots\ldots \\ f_{p1}f_{p2}\ldots f_{pk} \end{pmatrix}$

With a variance equal to:

$$Var(X_i) = \sum_{j=1}^{k} a_{ij}^2 + \Psi_i = h_i^2 + \Psi_i; i = 1,\ldots\ldots,p \tag{26}$$

Where:

$$h_i^2 = Var\left(\sum_{j=1}^{k} a_{ij}F_j\right) \ldots\ldots y \ldots\ldots \psi_i = Var(u_i) \tag{27}$$

This equation corresponds to the communalities and the specificity of the variable X_i. Thus the variance of each variable can be divided into two parts: a) in their communalities h_i^2 representing the variance explained by common factors, and b) the specificity Ψ_I that represents the specific variance of each variable.

Thus obtaining:

$$\mathrm{Cov}\,(X_i, X_l) = \mathrm{Cov}\left(\sum_{j=1}^{k} a_{ij}F_j, \sum_{j=1}^{k} a_{lj}F_j\right) = \sum_{j=1}^{k} a_{ij}a_{lj} \qquad \forall i \neq \ell \tag{28}$$

With the transformation of the correlation matrix's determinants, we obtained Bartlett's test of sphericity, and it is given by the following equation:

$$d_R = -\left[n - 1 - \frac{1}{6}\left(2p+5\right)\ln\left|R\right|\right] = -\left[n - \frac{2p+11}{6}\right]\sum_{j=1}^{p}\log(\lambda_j) \tag{29}$$

$$\left[n - \frac{2p+11}{6}\right] \log \frac{\left[\frac{1}{p-m}\left(trazR^* - \left(\sum_{a=1}^{m}\lambda_a\right)\right)\right]^{p-m}}{\left|R^*\right| \Big/ \prod_{a=1}^{m}\lambda_a} \tag{30}$$

3.1.1. Empirical study

Results

First, Table 2 shows the correlation between variables but, not are significant, example (like/motivation, sig. = 0.011, r = - .133; motivation/usefulness, sig. = 0.040 r =-. 102).

Table 2. Correlation matrix, KMO and Bartlett test

	Variable	Usefulness	Anxiety	Confidence	Liking	Motivation
Correlation	Usefulness	1.000	.230	.449	.663	**-.102**
	Anxiety	.230	1.000	.462	.175	-.412
	Confidence	.449	.462	1.000	.440	-.193
	Liking	.663	.175	.440	1.000	**-.133**
	Motivation	-.102	-.412	-.193	**-.133**	1.000
Sig. (Unilateral)	Usefulness		.000	.000	.000	**.040**
	Anxiety	.000		.000	.001	.000
	Confidence	.000	.000		.000	.000
	Liking	.000	.001	.000		**.011**
	Motivation	.040	.000	.000	.011	
Bartlett test of Sphericity			379.674 (α=0.00) df 10			
Measure of sampling adequacy (overall)			.648			

Source: own

Contrast Values Bartlett support the conclusion that the correlation matrix is significant (α = 0.00) when taken together all variables. The measure of overall sampling adequacy (MSA) is 0.648 is within the acceptable value (0.50). Examination of the values of each variable identifies that all variables, have values greater than 0.5 (table 3).

Table 3. Measure of sampling adequacy and partial correlation

Variable	Usefulness	Anxiety	Confidence	Liking	Motivation
Usefulness	**.649**[a]	-.072	-.185	-.583	-.044
Anxiety	-.072	**.602**[a]	-.392	.091	.376
Confidence	-.185	-.392	**.731**[a]	-.221	-.018
Liking	-.583	.091	-.221	**.628**[a]	.085
Motivation	-.044	.376	-.018	.085	**.610**[a]

Source: own

Now, in Table 4 shows the component matrix and communalities where we see two factors: first one composed of three elements: usefulness, confidence, liking and other incorporates two elements: anxiety and motivation. The values of this last factor indicate if the student anxiety increased, decreased motivation and their explanatory power for each factor are expressed by their Eigenvalue 2.351 and 1.198 respectively.

The values of the first and second column shows the factor loadings of each variable and the third column reveals how each variable is explained by the components. Thus, we see that the variable "usefulness" has a greatest weight, followed of liking, anxiety, motivation and finally the variable "confidence".

Table 4 Components Matrix and Communalities

Variables	Factor1	Factor 2	Communalities
Usefulness	**.883**	.055	.783
Anxiety	.210	**.825**	.724
Confidence	**.640**	.444	.606
Liking	**.878**	.038	.773
Motivation	.013	**-.814**	.663
Eigenvalue	2.351	1.198	
Variance %	47.016	23.964	
Total Variance			71.08%

Extraction Method: Principal Component Analysis.

Source: own

4. FINAL CONSIDERATIONS

The aim of study was to identify the factors that explain the attitude towards statistics in undergraduate students, for it was used the scale proposed by Auzmendi [1], which integrates the dimensions: liking, usefulness, confidence, motivation and anxiety as factors that influence the student's attitudes towards statistics.

The empirical results allow us to say that there are two factors that explain the phenomenon of study, and these are: Favorable attitude towards statistics composed by three factors (usefulness, anxiety, confidence) and other Unfavorable attitude toward statistics composed by two factors (anxiety and motivation).

Furthermore, the results reveal that when students see the usefulness of statistics, likes the subject and feel confidence to learn, however, if don't have a motivation for the study, this it causes of anxiety. These results are consistent with those presented by Auzmendi [1] who notes that the factors that have the greatest influence are those related to motivation, liking and the utility. In this sense Mondejar *et al* [10] suggest that anxiety and nervousness influence the student's attitude towards the field of statistics.

Based on the above, it is necessary implement actions that consider the motivational aspect to avoid the anxiety of students and to strengthen the strategies of statistics' application in each area of study chosen by the student in order to improve the attitude toward statistic considering their impact on learning of the subject according to Schutz, *et al* [32].

Furthermore, it is necessary for teachers who's teach the class should have statistical knowledge in the subject and the ability to motivate students, resulting in greater fruit in the teaching-learning process.

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