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# Modeling Attitude toward Statistics by a Structural Equation

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In this study, we examined whether the constructs of usefulness, motivation, likeness, confidence, and anxiety influence the student's attitude towards statistics. Two hundred ninety eight students enrolled in the private university were surveyed by using the questionnaire proposed by Auzmendi (1992). Data analysis was done by structural equation model AMOS software. The results support the model proposed by Auzmendi of five factors, however the data reveal that there exists an alternative model (CFI = 0.907) that best fits the proposed model (CFI = 0.885). Furthermore, of the 25 indicators proposed only 22 have an acceptable range and two of the indicators (Items 9 and 2) should be considered in the construct of anxiety and usefulness respectively.

*Keywords*: teacher conceptions, teacher education, visualization

## INTRODUCTION

As an extension of study of García, Venegas y Escalera (2013) "An exploratory factorial analysis to measure attitude toward statistics" (empirical study on undergraduate students), now we conduct a study in order to measure attitudes towards statistics trough modeling by a structural equation. The end goal was to determine if there exists an alternative model to the factors in the model proposed by Auzmendi (1992).

### Background

The earlier results (Garcia et al, 2013) point out that there are two factors that explain the phenomenon at the focus of this study: the favorable attitude towards statistics that are composed of three factors (i.e. usefulness, anxiety, and confidence) and unfavorable attitude towards statistics composed of two factors (i.e. anxiety and motivation). Furthermore, these results show that when students see the usefulness of statistics in professional life, then they can like the topic, which gives them confidence to learn; however if they are not motivated, then anxiety can arouse. These findings are consistent with those reported by Auzmendi (1992) who pointed out that the factors of greater influence are those related to motivation, liking, and utility.

Furthermore, there is another empirical referent, the work of Mondejar et al (2008) who suggest that anxiety and nervousness have an influence on students' attitudes towards statistics. They conclude with several recommendations on the possible implementation of the measures that integrate the motivational aspect, which could avoid the students' anxiety and with this, strengthen strategies of teaching statistics in every area of study chosen by the student in order to improve the

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***State of the literature***

- Many types of study described some test inventories that measure specifically the students' attitude towards statistics
- Attitude survey is widely used definition and measurement of attitudes towards statistics
- In recent years studies have shown that all arguments mentioned above as a theoretical framework in order to understand the attitude toward statistical in undergraduate students

***Contribution of this paper to the literature***

- This study explores the constructs of usefulness, motivation, likeness, confidence, and anxiety influence the student's attitude towards statistics
- Currently many organizations are recognizing that to test their products and policies in real environments, gives them significant results, i.e., are committing themselves to apply statistical knowledge to make better decisions with accurate elements
- This leads us to wonder if the college student is ready to participate in the challenges of the business world, which leads at first instance, to assess what is the behavior which the learner has made the subjects related to mathematics, and in this case with statistics in order to identify opportunity areas for develop the ability make decisions

attitude towards statistics taking into account the impact that may generate in the process of learning of this course as refers Schutz, et al (1997).

Additionally, it is necessary that instructors who "teach the course" should have knowledge of statistics on the subject and the capacity to motivate students, resulting in greater effectiveness in the teaching-learning process.

## Literature review

Blanco (2008) conducted a critical review of the literature about students' attitudes toward statistics. In his study described some test inventories that measure specifically the students' attitude towards statistics. In his study referred to the research of Glencross y Cherian (1992) who cited the most important studies in the Anglo-Saxon context such as: Statistics Attitudes Survey- SAS Roberts y Bilderback (1980), Attitudes toward Statistics- ATS Wise (1985 ), Statistics Attitude Scale McCall, Belli y Madjini (1991), Statistics Attitude Inventory (Zeidner, 1991), Students' Attitudes Toward Statistics Sutarso (1992 ), Attitude Toward Statistics Miller, Behrens, Green y Newman (1993), Survey of Attitudes Toward Statistics – SATS Schau, Stevens, Dauphinee y Del Vecchio (1995), Quantitative Attitudes Questionnaire Chang (1996) among other.

In short, one of the first operative definition and measurement of attitudes towards statistics is the test of Roberts and Bildderbach (1980) 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 (García et al, 2013).

Continuing with the theoretical explanation of this subject, Mondejar, Vargas and Bayot, (2008) developed a test based on the methodological principles of Wise (1985) attitude toward statistic (ATS) and scale attitude toward statistics (SATS) of Auzmendi (1992). Mondéjar et al (2008) describe the psychometric properties of this new scale to measuring attitude toward statistics. With this result they obtained a tool for measuring or quantifying students' affective factors. This scale may show the level of nervousness-anxiety and other factors such a gender. All this could affect students´ attitude like say Phillips (1980), he refers that the students' attitude can suppose an obstacle or constituted and advantages for their learning.

Roberts y Saxe (1982); Beins (1985); Wise (1985); Katz y Tomezik (1988); Vanhoof et al (2006); Evans (2007) showed the relationship between attitude toward statistic and academic outcomes or the professional use of this tool. They confirmed the existence of positive correlation between students' attitudes and their performance in this area. In Spain, Auzmendi (1992), Sánchez-López (1996) y Gil (1999) confirmed the existence of positive correlation between students' attitudes and their performance.

Additionally, important arguments are exposed by Auzmendi (1991), Gal & Ginsburg (1994) and Ginsburg & Schau (1997) about students' statistics attitudes. They assert that the attitudes towards statistics is an essential component of students' background with which, after a university education, may continue through academic and professional activities. Other studies attempted to measure the work underlying this issue (e.g. scale ATS proposed by Wise (1985) and the scale of Auzmendi (1992) gathered students most relevant characteristics regarding their attitudes towards statistics, their difficulties with the mathematical factors and prejudices). Out of these, derivative works such as Elmore and Lewis (1991) and Schau et al (1995) have emerged. The ATS scale (Wise, 1985) is consists of 29 items grouped in two sub-scales, one measuring the affective relationship with learning and cognitive measures the perception of the student with the use of statistics.

**Table 1**. Scale Factors Attitude towards Statistics (García et al; 2012).

| Indicators | Definition | Code/items |
|---|---|---|
| Likeness | 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 |

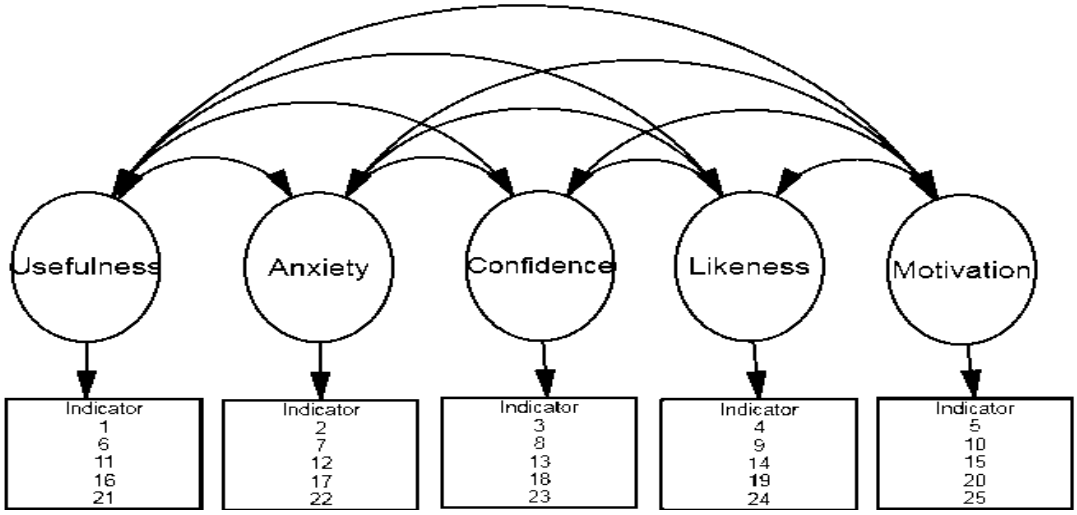


**Figure 1.** Sequence Diagram

Mondéjar et al (2008) refer to that initially validation was based on a sample very small, and was with subsequent studies such as Mondejar et al (2008) or Woehlke (1991) 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.

Finally, and considering all arguments mentioned above as a theoretical framework in order to understand the attitude toward statistical in undergraduate students: and considering that this study seeks to find answers to the research questions about of attitude towards statistic in undergraduate students, we use the scale SATS proposed by Auzmendi, thus, it set the following:

Question, objective and hypothesis

*RQ1. What factors can help explain the attitude toward statistic in college students?*

*So1. Develop a theoretical model that integrates the factors that explain attitude toward statistic.*

*So2. Evaluate the model using the elements of each factor.*

*So3. Evaluate the adjusted model.*

*Hi1: There are factors that can help explain the attitude toward statistic in undergraduate students*

## METHODOLOGY

### Kind of study, population, instrument

This study is non-experimental, transactional and confirmatory, because we need to know the college students' attitudes towards statistics in a private university. The sample was selected for the trial of non-probability sampling. A total of 298 students' were surveyed at Cristóbal Colón University from several profiles in 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 towards statistics (SATS).

**Table 2**. Weightings of the constructs

| | Usefulness | Anxiety | Confidence | Likeness | Motivation |
|---|---|---|---|---|---|
| Variable | Item 1 | Item 2 | Item 8 | Item 4 | Item 5 |
| Weighting Significance | 0.793 | 0.702 | 0.702 | 0.711 | 0.665 |
| Variable | Item 6 | Item 17 | Item 13 | Item 9 | Item 10 |
| Weighting Significance | 0.704 | 0.732 | 0.69 | 0.599 | 0.534 |
| | 11.610 | 10.403 | 9.130 | 9.433 | 6.387 |
| Variable | Item 11 | Item 22 | | Item 14 | |
| Weighting Significance | 0.624 | 0.743 | | 0.794 | |
| | 10.241 | 10.497 | | 12.224 | |
| Variable | Item 21 | | | Item 19 | |
| Weighting Significance | 0.627 | | | 0.69 | |
| | 10.301 | | | 10.793 | |
| Variable | | | | Item 24 | |
| Weighting Significance | | | | 0.688 | |
| | | | | 10.764 | |

**Table 3.** Correlation between constructs

| | Usefulness | Anxiety | Likeness | Motivation | Confidence |
|---|---|---|---|---|---|
| Usefulness | 1 | 0.380 | 0.770 | -0.509 | 0.546 |
| Anxiety | | 1 | 0.360 | -0.699 | 0.676 |
| Likeness | | | 1 | -0.238 | 0.658 |
| Motivation | | | | 1 | -0.222 |
| Confidence | | | | | 1 |

**Table 4**. Measures Goodness of Fit: Revised model and null

| | |
|---|---|
| Chi-square ( $X^2$) | 236.851 |
| Degree of freedom (df) | 94 |
| Significance level (sig.) | 0.000 |
| Normed Chi-square ( $X^2/gl$ ) | 2.374 |
| Goodness of Fit Index (GFI) | 0.913 |
| Adjusted Goodness of Fit Index (AGFI) | 0.874 |
| Root Mean Square Error of Approximation (RMSEA) | 0.072 |
| Tucker Lewis Index (TLI) | 0.893 |
| Normed Fit Index (NFI) | 0.869 |

The scale SATS proposed by Auzmendi (1992) indicates the existence of five factors: usefulness, anxiety, confidence, pleasure and motivation. The usefulness factor indicators are as follows: Item 1, 6, 11, 16, 21; anxiety factor indicators are as follows: Item 2, 7, 12, 17, 22; the confidence factor are as follows: items 3, 8, 13, 18, 23; likeness factor indicators are as follows: Item 4, 9, 14, 19, 24. Finally indicators belonging to motivational factor are as follows: items 5, 10, 15, 20, 25. The diagram of factors sequences is shown in figure 1 and the table 1 described the indicators, definitions and codes/items (García et al, 2012).

**Statistical procedure**

If we considering that the Structural equation modeling (SEM) is a technique for testing hypothesized relationships among variables by estimating a series of separate, still interdependent, multiple regressions simultaneously, therefore the use of SEM is considered appropriate for this research due to its great potential for extending the theory development and its capability of simultaneously assessing the multiple and interrelated dependence relationships (Gefen, et al. 2000).

Furthermore, this study integrates latent variables representing unobserved concepts, which is possible by using SEM due to its ability to include latent variables while accounting for measurement error in the estimation process (Hair, et al. 1998). If we start from the objectives that were set; So2 Evaluate the model using the elements of each factor and So3 Evaluate the adjusted model, therefore this study uses two-step approach to SEM; a measurement model and a structural model.

A measurement model is estimated followed by an estimation of structural model. The measurement model involves in development of a confirmatory factor analysis (CFA) that allows assessing the contribution of each indicator variable and for measuring the adequacy of the measurement model.

The measurement model involves in conducting a confirmatory factor analysis (CFA) for assessing the contribution of each indicator variable and for measuring the adequacy of the measurement model.

*The first step in analyzing CFA is the model specification.*

*The second step is an iterative model modification process for developing a more parsimonious set of items to represent a construct through refinement and retesting.*

*The third step is to estimate the parameters of the specified model.*

*The overall model fitness is evaluated by several measures of goodness of test to assess the extent to which the data supports the conceptual model.*

Various Goodness of Fit (GOF) measures used in this study include the likelihood ration chi-square ($X^2$), the ratio of $X^2$ to degrees of freedom ($X^2/df$), the Goodness of Fit Index (GFI), the Adjusted Goodness of Fit Index (AGFI), the Root Mean Square Error of Approximation (RMSEA) and Tucker-Lewis (TLI) index (Hair, et al. 1998).

The guidelines for acceptable values for these measures are discussed below. A non-significant $X^2$ ($p>0.05$) is considered to be a good fit for the $X^2$ GOF measure. However it is believed that this does not necessarily mean a model with significant $X^2$ to be a poor fit. As a result consideration of the ratio of $X^2$ to degrees of freedom ($X^2/df$) is proposed to measure as an additional measure of GOF. A value smaller than 3 is recommended for the ratio ($X^2/df$) for accepting the model to be a good fit (Chin, et al. 1995).

The GFI is developed to overcome the limitations of the sample size dependent $X^2$ measures as GOF (Joreskog, et al. 1993). A GFI value higher than 0.9 is recommended as a guideline for a good fit. Extension of the GFI is AGFI, adjusted by the ratio of degrees of freedom for the proposed model to the degrees of freedom for the null model. An AGFI value greater than 0.9 is an indicator of good fit (Segars, et al 1993)

RMSEA measures the mean discrepancy between the population estimates from the model and the observed sample values. RMSEA < 0.1 indicates good model fit (Browne, et al. 1993; Hair, et al. 1998). TLI, an incremental fit measure, with a value of 0.9 or more indicates a good fit (Hair, et al. 1998). Except for TLI, all the other measures are absolute GOF measures. The TLI measure compares the proposed model to the null model.

Based on the guidelines for these values, problematic items that caused unacceptable model fit were excluded to develop a more parsimonious model with limited number of items.

## DATA ANALYSIS AND DISCUSSION

### Empirical study

Firstly, we should evaluate the results in order to see that there are no estimates infringing. In Table 2 shows the weights of each of the indicators that make up each construct. It can be seen that none of the standardized coefficients have exceeded or are close to 1. Moreover, the measurement error values for all indicators are positive as shown in Table 3.

Regarding the correlations between constructs --the values obtained-- none have values greater than 1.0 (Table 4), at the same time, we can see a close association between the constructs: usefulness, anxiety, likeness, motivation and confidence

Global adjusted of model. Table 5 provides the quality measures of absolute fit. Although the chi-square statistic (236,851, $df$ = 94) is not significant (0.000), indexes showed a satisfactory fit. The values of GFI (0.913), AGFI (0.874) and RMSR (.072) are satisfactory because their values tend to 1 and are > of .5

**Table 5.** Reliability and variance of constructs

| Indicators | Reliability | Extracted means variance |
|---|---|---|
| Usefulness (U) | 0.783 | 0.476 |
| Anxiety (A) | 0.769 | 0.526 |
| Likeness (L) | 0.657 | 0.489 |
| Motivation (M) | 0.825 | 0.488 |
| Confidence (C) | 0.530 | 0.363 |

**Table 6.** Discriminant validity

| | Usefulness | Anxiety | Confidence | Likeness | Motivation |
|---|---|---|---|---|---|
| Usefulness (U) | 0.690 | 0.144 | 0.592 | 0.259 | 0.298 |
| Anxiety (A) | | 0.726 | 0.129 | 0.488 | 0.456 |
| Confidence (C) | | | 0.602 | 0.056 | 0.432 |
| Likeness (L) | | | | 0.700 | 0.049 |
| Motivation (M) | | | | | 0.700 |

**Adjusted model of measure**

Upon acceptance the model (as a set), were evaluated each of the constructs in order to check the internal consistency of all indicators to measure the concept. The results in Table 6 indicate that the reliability values related to the constructs range from 0.530 onwards (>), it means that not all indicators are consistent with its measure.

The table shows also, extracted variance, which must be higher than 0.50 in this case, the values of one of the construct are below 0.5 (motivation) which means, that more than half of the variance of the indicators is not taken into account for the construct. In addition, confidence and pleasant constructs are very close to 0.500, which is a recommended value for the average variance extracted (Fornell and Larcker, 1981, cited by Calvo de Mora and Criado, 2005).

Regarding discriminant validity, the values showed in Table 7 reveal that all are less than 1; it means, that none of the items that were part of the different factors, shown in the other constructs.

Thompson (2004) notes, that the confirmatory factor analysis type, we should confirm the theoretical model fit, because it is recommendable to compare the fit indexes of several alternative models to select the best. Therefore, we proceeded to verify the model obtained from exploratory factor analysis, which included paths between latent variables, and we estimate the model (see Figure 2).

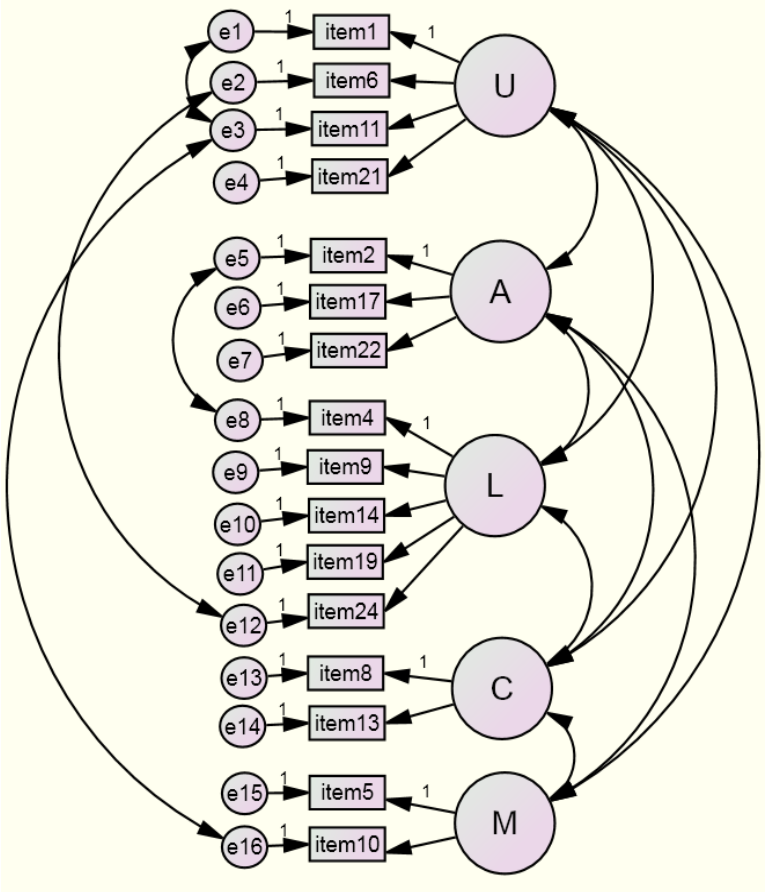


**Figure 2.** Sequence Diagram

**Table 7**. Measures of Goodness Fit (Model 2)

| | |
|---|---|
| Chi-square ( $X^2$) | 151.580 |
| Degree of freedom (*df*) | 88 |
| Significance level (sig.) | 0.000 |
| Normed Chi-square ( $X^2/gl$ ) | 1.722 |
| Goodness of Fit Index (GFI) | 0.940 |
| Adjusted Goodness of Fit Index (AGFI) | 0.970 |
| Root Mean Square Error of Approximation (RMSEA) | 0.049 |
| Tucker Lewis Index (TLI) | 0.949 |
| Normed Fit Index (NFI) | 0.916 |

**Re-specification of model**

Reviewing the criteria in terms of their optimal values, we can see that there are values indicating a model with a poor fit. Therefore, it is obvious and necessary to make some changes in specifications to identify a model that best represents the data. From this moment, the estimate represents the exploratory analysis and then model proposed modifications were made by examining the normalized residuals and modification indexes.

Thus, the re-specification of hypothesized model, involved the addition of estimated parameters for the model, resulting in a model 2. Incorporating covariates in model 2 and the specification of item 9, reflecting improved considerably large for model fit (Table 7).

In an alternative model (model 2-figure 3) specifies the item 9 as motivation construct load, instead of the construct that was originally designed (Figure 2). Re-specification model values are shown in Table 8.

When comparing the results of model 1 and model 2, we can see that the value of Chi-square (X2) decreased from 236.851 to 151.58 and the value of RMSEA decrease of 0.072 to 0.049, while the goodness of fit indexes GFI and AGFI improved from 0.913 to 0.940 and from 0.874 to 0.970 respectively. In the same way, the incremental fit measures (TLI and NFI) have enriched and exceed the recommended level of 0.90. Regarding the error covariances, these suggest a redundancy between items 1 and 11, 2 and 12, and 10 and 11 due to overlapping content.

## CONCLUSION

In sum, the objective of this work was to analyze the attitudes toward statistics trough a model that considers the proposed variables by Auzmendi (1992). The theoretical model formulated tries to prove that: usefulness, motivation, likeness, confidence, and anxiety have impact on student's attitudes towards statistics.

The results support the model proposed by Auzmendi with five factors, however the data reveals that there is an alternative model (CFI = 0.907) that best fits the proposed model (CFI = 0.885). Furthermore, of the 25 indicators proposed only 22 have an acceptable range and two of the indicators (Items 9 and 2) should be considered in the construct of anxiety and usefulness respectively.

Regarding to the correlation among the factors, it is confirmed that these three factors are correlated. In which it corresponds to the association of errors, the outcomes reveal that there is superimposition in the contents among the items which correspond to the errors: 1 and 3, 5 and 8, 2 and 12, 3 and 16 which is

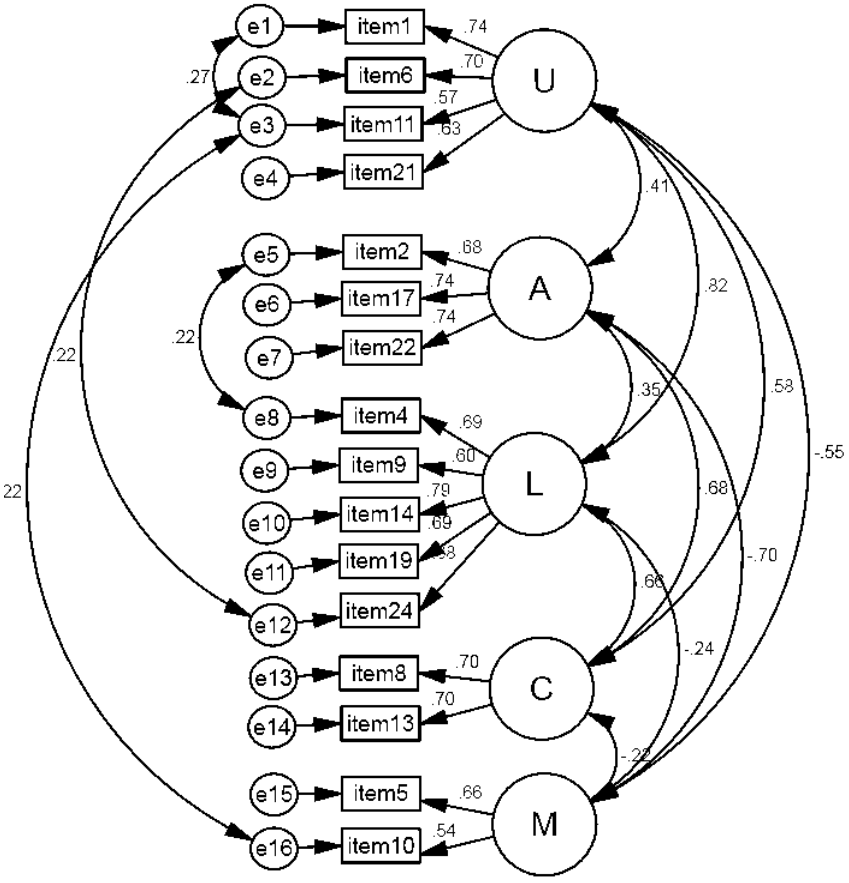


**Figure 3**. Model 2 Factorial structure of Auzmendi

evident that these items present a problem and definitively needed a review of its contents for this context.

Finally, as a suggestion, it is appropriate to review the contents of the measuring instrument, testing the model and compare the results with other students from several countries and postgraduates, all suggested as future research in this area.

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