Measurement Of Students Attitude Towards Statistics: A Mokken Scales Analysis Of Its Dimensions

Manuel Vargas-Vargas, Ph.D., University of Castilla-La Mancha, Spain
José Mondéjar Jiménez, Ph.D., University of Castilla-La Mancha, Spain
Mª Leticia Meseguer-Santamaría, University of Castilla-La Mancha, Spain
José-María Montero-Lorenzo, Ph.D., University of Castilla-La Mancha, Spain
Gema Fernández-Avilés, Ph.D., University of Castilla-La Mancha, Spain

ABSTRACT

Nowadays, almost all curricula in the social sciences contain at least one course in statistics, given the importance of this discipline as a basic knowledge to understand the modern world. It's necessary reflects on the student's attitude to statistics, because it's could be an obstacle or an advantage in their learning process. To measure the student's attitude and incentives about statistics, we use a test (Bayot et al., 2005), related to other ones which exists in the specialized literature, that identifies the latent factors relating to students' motivation and attitude towards statistics. This paper describes the formal and metric characteristics of the non-parametric model of item response theory for the latent factors using an extension of Mokken scales analysis.

Keywords: Learning Statistic; Latent factors; Non-Parametric Item Response Model; Mokken Scales Analysis

INTRODUCTION

The influence of cognitive and affective factors in the students' attitude and performance in the learning of statistics has been widely discussed in the literature (Roberts and Saxe, 1982; Beins, 1985; Wise, 1985; Katz and Tomezik, 1988; Gil, 1999; Bayot *et al.*, 2005; Mondéjar, Vargas and Bayot, 2008; Mondéjar and Vargas, 2010). However, there is still no consensus on the theoretical foundation of this influence (Carmona, 2004), nor on how to operationalize concepts that have different shades and are not directly observables. Following Auzmendi (1992, p. 17), we mean attitudes as "aspects are not directly observable but inferred, made both by the beliefs and the feelings and behavioral predispositions toward the object at that address". The most important attitudes are those of the affective component—the domain in which researchers have shown most interest. Several works study the anxiety construct in education and its relation with academic performance (Seipp, 1991; Hardy and Hagtvet, 1996), and show that modify the students' level of anxiety can translate into improved academic performance.

In this paper, we use a questionnaire about attitude towards statistics developed in Bayot *et al.* (2005), which decomposes attitude into two subscales, one affective and the other evaluative, both bi-dimensional in structure. In the affective subscale, one factor measures the degree of interest in the subject, and the other, the level of students' anxiety when tackling statistics problems. The valorative subscale also consists of two components, one measuring the utility students perceive for their current studies, and the other, the utility for their future professional career. This latent structure is similar to other scales proposed in the literature (Wise, 1985; Waters *et al*., 1988; Elmore and Lewis, 1991; Woehlke, 1991; Auzmendi, 1992; Schau *et al.*, 1995; Gil, 1999; Darias, 2000). In these works, the structure always contains factors relating to both the affective and evaluative components, but they tend to disagree on the number of variables they use to operationalize each component. Searching out existing standard scales and measures for constructs is therefore often an important early step in the research process.

While in the education literature are not consensus on how to operationalize these constructs (often there is no one perfect way to operationalize its), the developed scales should be validated and their phicometric characteristics analysed. If scales are defined as sets of items which stand in ordinal relationship to each other, then Mokken scales meet this test of ordinality between items. In this case, the coefficients of scalability and reproducibility are tests of whether items are sufficiently in an ordinal relationship to justify their combination in an index (Mokken and Lewis, 1982). Loevinger's coefficient H measures the conformity of a set of items to Mokken's criteria and validates their use together as a scale of a unidimensional latent variable (Sijtsma and Verwey, 1992).

The aim of this paper is to evaluate the quality metrics of the used questionnaire for measuring students' attitudes towards statistics, adapted to the proposed structure. Specifically, each of the four dimensions should consist of items that are added one-dimensional and which satisfy the monotonous uniformity. To this end, we applie a nonparametric item response model which generalizes that of Mokken (Mokken, 1971, 1997), called strong model of double monotony (Sitjsma and Hemken, 1998), given the nature of the data obtained by the Bayot *et al.* questionnaire.

DATA COLLECTION AND METHOD

The empirical study uses a sample of 374 students from the University of Castilla-La Mancha (Spain) enrolled on a unit with statistical content for the first time during their university studies. The study has an ex-post-facto design, and took place in the second week of classes, in order to ensure that the results were not biased by factors such as the progress of the unit, the performance of the teacher, or the partial results obtained.

Mokken model, and its derivates, assuming the existence of a latent scale (θ) related to the empirical scale used as measure (X), usually obtained by adding the scores of each of the items. But it needs some metric conditions to ensure the inferences made based on the first by the second (Elosua, 2006):

- Stochastic Ordering of Empirical Scale (SOES). The order of individuals on the latent scale produces a stochastically correct order on the empirical scale. Given two individuals, A and B, with levels in the latent scale θ_A and θ_B such that $\theta_A<\theta_B$, this property states that for any empirical score x:

$$P(X \geq x / \theta_A) \leq P(X \geq x / \theta_B)$$

- Stochastic Ordering of Latent Scale (SOLS). The order of individuals on the empirical scale produces a stochastically correct order of individuals on the latent scale. For a constant value in the latent variable (s) and for two empirical values x_1 and x_2 such that $x_1 < x_2$:

$$P(\theta > s / X=x_1) < P(\theta > s / X=x_2)$$

The evaluation of these conditions is based on empirical verification of some properties. The monotony can be assessed by the Loevinger's scalability coefficient, H_{ij}:

$$H_{ij} = 1 - \frac{\sum_i \sum_j w_{ij} n_{oij}}{\sum_i \sum_j w_{ij} n_{eij}}$$

where w_{ij} is the number of errors in the pattern ij, n_{oij} is the number of responses observed in the response pattern ij and n_{eij} is the number of expected responses in the pattern ij under the assumption of independence.

Although there is a test for evaluate their significance (Molenaar and Sijstma, 2000), because of low power, it is usual to consider values equal to or above 0.3 as significant (Mokken, 1971).

STATISTICAL RESULTS

To evaluate the psychometric properties of the questionnaire on attitudes towards statistics of Bayot *et al.* (2005), we have estimated the coefficients of scalability, Hi, by the software routine Mokken for statistical software R.

Table 1 shows factorial structure of the questionnaire, obtained by factorial analysis (Mondéjar and Vargas, 2010). Each empirical scale is estimated by aggregation of items, weighted by rotated factor loadings.

Table 1: Rotated Factor Loadings

Item	F1: Interest	F2: Anxiety	Item	F3: Pres. Util.	F4: Proff. Util
Item nº 15	0.764		Item nº 10	0.690	
Item nº 17	0.759		Item nº 25	0.655	
Item nº 14	0.737		Item nº 16	0.593	
Item nº 13	0.735		Item nº 3	0.533	
Item nº 24	0.671		Item nº 5		0.746
Item nº 18	0.537		Item nº 20		0.679
Item nº 9		0.735	Item nº 11		0.555
Item nº 7		0.722	Item nº 26		0.552
Item nº 22		0.706	Item nº 6		0.550
Item nº 21		0.702	Item nº 4		0.520
Item nº 23		0.643	Item nº 2		0.519
Item nº 12		0.633	Item nº 19		0.501
Item nº 1		0.557	Item nº 27		0.497

To assess the monotonicity of the four empirical scales, Loevinger's scalability coefficients, H_{ij}, were estimated for each pair of items. From them, we obtain the scalability coefficients for each item, H_i, adding the corresponding H_{ij} for all other items, as shown in Table 2:

Table 2: Loevinger's Scalability Coefficients H_i

Item	F1: Interest	F2: Anxiety	Item	F3: Pres. Util.	F4: Proff. Util
Item nº 15	0.587		Item nº 10	0.433	
Item nº 17	0.600		Item nº 25	0.383	
Item nº 14	0.594		Item nº 16	0.409	
Item nº 13	0.565		Item nº 3	0.369	
Item nº 24	0.543		Item nº 5		0.295
Item nº 18	0.426		Item nº 20		0.283
Item nº 9		0.469	Item nº 11		0.438
Item nº 7		0.450	Item nº 26		0.492
Item nº 22		0.492	Item nº 6		0.420
Item nº 21		0.491	Item nº 4		0.449
Item nº 23		0.417	Item nº 2		0.444
Item nº 12		0.418	Item nº 19		0.317
Item nº 1		0.378	Item nº 27		0.382

Finally, we estimate the scalability coefficients for each empirical scale adding the H_i for the constitutive items. Table 3 shows, for each factor, the Loevinger's coefficients H, and the empirical mean and standard desviation.

Table 3: Coefficient H, Mean and Standard desviation of escales

Scale	H	Mean	Standard Desviation
F1: Interest	0.5555	2.56	0.92
F2: Anxiety	0.4469	3.26	1.00
F3: Present utility	0.3979	3.40	0.98
F4: Professional utility	0.4213	3.47	0.93
Total of escales		3.17	0.96

In all cases, the scalability coefficients are significant, indicating that the obtained empirical scales adhere to the principle of monotonicity. This ensures the one-dimensional for the empirical scales, reflecting the existence of latent scales for each of the dimensions analyzed (Junker and Sijtsma, 2000).

In a descriptive analysis of the scales, we note the low level of interest in statistics, they find most useful for their future careers than for their present studies. Also, the raised level of anxiety in students is above the central value of the scale.

CONCLUSIONS

In this paper, we have evaluated the psychometric properties of a questionnaire designed to assess students' attitudes towards statistics. The questionnaire has two subscales, an affective and other evaluative, both with two-dimensional structure. In all cases, the Loevinger's scalability coefficients, H, are close to or above 0.4, indicating that the obtained factor structure is appropriate: the four empirical scales are significant, monotonous and consist of items that are added unidimensionally. Thus, the estimate scales can be used as a substitute for latent scales in the study of affective and evaluative components that influence students' attitudes towards statistics.

Globally, the results confirm a model that can offer guidance about how educators can reduce students' level of anxiety with respect to statistics. Specifically, if educators can familiarize their students about the social applications of statistics, this should reinforce their perception of the utility of this discipline for their current studies and increase their interest in studying the subject. These effects should indirectly translate into a reduction in the students' level of anxiety. Likewise, efforts to directly boost students' interest in statistics or their perception of its utility in their current studies should also reduce their level of anxiety.

Efforts to reduce the level of anxiety-nervousness should lead to improved academic performance in statistics among students, so this model could help educators design strategies to do this, or provide a means of evaluating the effectiveness of such strategies.

AUTHOR INFORMATION

Manuel Vargas-Vargas: PhD in Economics by University of Castilla-La Mancha and Degree in Mathematics by University of Granada. Associate Professor in Statistics at Statistics Department. Faculty of Economics and Business Administration of Albacete, University of Castilla-La Mancha (Spain). E-mail: Manuel.Vargas@uclm.es.
Research Interest: disability, regional analysis, educational and tourism.

José Mondéjar-Jiménez: European PhD in Economics and Degree in Business Administration by University of Castilla-La Mancha. Associate Professor at Statistics Department. Faculty of Social Sciences of Cuenca. University of Castilla-La Mancha (Spain). E-mail: Jose.Mondejar@uclm.es.
Research Interest: disability, regional analysis, educational and tourism.

María-Leticia Meseguer-Santamaría: MBA in Economics Degree in Business Administration by University of Castilla-La Mancha. Assistant Professor in Statistics at Statistics Department. Faculty of Economics and Business Administration of Albacete. University of Castilla-La Mancha (Spain). E-mail: MLeticia.Meseguer@uclm.es.
Research Interest: disability, women studies, educational and tourism.

José-María Montero: He is PhD in Economics and Business Administration, Autonomous University of Madrid, Spain. Currently his position is Full Professor in Statistics at the Department of Statistics, Faculty of Law and Social Sciences, University of Castilla-La Mancha, Spain. E-mail: Jose.MLorenzo@uclm.es.
Research Interest: qualitative data, geostatistics, educational and tourism.

Gema Fernández-Avilés: She is European PhD in Economics and Business Administration, University of Castilla-La Mancha, Spain. Currently his position is Assistant Professor in Statistics at the Department of Statistics, Faculty of Law and Social Sciences, University of Castilla-La Mancha, Spain. E-mail: Gema.FAviles@uclm.es.
Research Interest: qualitative data, geostatistics, educational and tourism.

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