Revista ELectrónica de Investigación y EValuación Educativa

RELIEVE

e-Journal of Educational Research, Assessment and Evaluation

ISSN: 1134-4032

Attitudes towards statistics of education Sciences students. Psychometric properties of the Spanish version of the Survey of Attitudes Towards Statistics (SATS-36)

Actitudes hacia la estadística en estudiantes de Ciencias de la Educación. Propiedades psicométicas de la versión española del Survey of Attitudes Toward Statistics (SATS-36)

Rodríguez-Santero, Javier & Gil-Flores, Javier
University of Seville (Spain)

Abstract

The study of attitudes towards statistics is a topic which has aroused the interest of researchers in different countries and ~~at~~ teaching levels. In this work we present an analysis of the psychometric properties, in terms of structural validity and internal consistency, of a Spanish version of the Survey of Attitudes Towards Statistics (SATS-36) administered to education students. The results obtained from the 409 participants indicate a lack of fit for the six-factor model proposed by the authors of the SATS, especially compared with the five-factor model with corrected mistakes that the authors of this work propose. These results coincide with what has been defended by other investigations as to the reduction of the number of attitudinal components measured with the SATS

Keywords: Psychometrics, factor analysis, student attitudes, statistics, university

Reception Date
2018 June 27

Approval Date
2019 March 05

Publication Date:
2019 March 05

Resumen

El estudio de las actitudes hacia la estadística es un tópico que ha suscitado el interés de investigadores en diferentes países y niveles de enseñanza. En el trabajo aquí presentado se expone un análisis de las propiedades psicométricas, en términos de validez estructural y consistencia interna, de la aplicación, en el contexto universitario nacional, del conocido *Survey of Attitudes Toward Statistics* (SATS), en su versión de 36 ítems. Los resultados obtenidos a partir de los 409 participantes, indican falta de ajuste para el modelo de seis factores propuestos por los autores del SATS, sobre todo, en comparación con el modelo de cinco factores con errores corregidos que proponen los autores de este trabajo. Estos resultados coinciden con lo defendido por otras investigaciones en cuanto a la reducción del número de componentes actitudinales medidos con el SATS.

Palabras clave: Psicometría, análisis factorial, actitudes de los estudiantes, estadística, universidad

Fecha de recepción
2018 Junio 27

Fecha de aprobación
2019 Marzo 05

Fecha de publicación
2019 Marzo 05

Statistics are a useful tool to get things done in a world in which numerical data and their treatment are present in very diverse domains. Beyond the statistics literacy necessary in citizens, a statistics competence is indispensable in the training of professionals

Corresponding author / Autor de contacto
Gil-Flores, Javier. University of Seville (Spain) jflores@us.es

of different fields. In higher education statistics are a transversal subject, included in the study plans designed for degrees assigned to different areas of university teaching. Statistics techniques tend to be addressed in subjects studied in the first year, and a significant number of students have to make use of them when doing their final degree projects, frequently focused towards empirical studies in which quantitative data need to be analysed.

The attitudes of students towards study subjects is a topic which has sustained the interest of researchers over time. The reason for this is the fact that attitudes are a key factor for learning. A positive attitude predisposes to effort, to involvement in work and contributes to academic success (Bourne, 2018). On the other hand, negative attitudes are one of the major obstacles for learning (Waters, Martelli, Zakrajsek & Popovich, 1988) and can lead students to disinterest, inhibition and study block, poor results being attained (Blanco, 2008), and even condition the choice of the career in those who are ready to begin university studies in the Social Sciences area (Bourne & Nesbit, 2018). In this sense, attitudes towards subjects of a logic-mathematical content are possibly those which have to a greater extent centred and continue centring the attention of researchers (Haladyna & Shaughnessy, 1982; Ma & Kishor, 1997; Osborne, Simons & Collins, 2003). In particular, the study of attitudes towards statistics among university students is a broadly addressed topic in the scientific literature, which remains relevant both in and out of the Spanish context, as reflected in the recent works of Carillo, Galy, Guthrie and Vanhems (2016), Comas, Martins, Nascimento and Estrada (2017), Ruiz de Miguel (2015), Sulieman (2015), Vilá and Rubio (2016) and Walker and Brakke (2017).

The teaching of statistical concepts poses special didactic problems in fields in which students do not have a mathematic basis as broad as that which characterises students of scientific careers (Blanco, 2008). Many students tend to face statistics subjects with negative preconceptions and attitudes towards the subject, usually associated with high levels of anxiety when they face ~~the~~ statistics classes, exercises or exams (Carmona, 2004). This is a problem for the teaching processes, given the potential relation between learning and attitude towards the study subject (Estrada, 2002).

Onwuegbuzie and Wilson (2003) classify the reasons or causes which give rise to negative attitudes towards statistics into three categories: situational, dispositional and environmental. Previous knowledge of statistics is among the situational reasons. This experience comes from the knowledge acquired in daily life outside the classroom, basically through the press or the media (Gal & Ginsburg, 1994). Another situational cause is related to statistics subjects studied, that is to say the previous learning experiences in the school context (Comas, Martins, Nascimento & Estrada, 2017). The dispositional causes refer to the students' behaviours and aptitudes, with ~~the~~ self-concept having a special relevance in subjects of a mathematical content. Lastly, Onwuegbuzie and Wilson (2003) include environmental causes related with the cultural context and the students' socio-demographic characteristics.

An interest in attitudes towards statistics lies in the negative predisposition of many university students concerning this subject, as they do not recognise its value and feel uncomfortable regarding the challenge of studying it. In specific degrees, mainly drawing on students who studied A-levels in Humanities and Social sciences, a large proportion of these students tend to have trouble learning statistic concepts. As Peter, Smith, Middledorp, Karpin, Sin and Kilgore (2013) state, statistics can prove to be abstract, and require logical reasoning, critical thought and skills for the interpretation and the extraction of conclusions. All of this generates perceptions of difficulty which reduce the expectations of success in the learning. The difficulties perceived by the students can be accompanied by disinterest, stress, anxiety and, in general, unsuitable attitudes for tackling the study of statistics.

The relations between attitudes towards statistics and performance have been analysed in numerous scientific works, in most cases showing that a positive attitude is associated with a higher performance in the students. The meta-analysis carried out by Emmioglu and Capa-Aydin (2012) concerning studies done between 1998 and 2011 is confined to works which use the SATS as an instrument to measure the activities of university students. They found a significant positive relation between both variables, with global effect sizes which ranged between 0.20 and 0.30 depending on what the component of the attitudes is that the attention is focused on. Some works have addressed the analysis of academic performance in statistics constructing structural equation models in which the attitudes towards statistics are included along with variables such as anxiety, previous performance or mathematical skills, among others (Chiesi & Primi, 2010; Hood, Creed & Neumann, 2012; Sesé, Jiménez, Montaño & Palmer, 2015; Tempelaar, van der Loeff & Gijselaers, 2007). In these models, the attitudes of the students have turned out to be the main, or one of the main, variables which predict the performance of university students.

The difficulties found by students in the study of statistics, along with the value of attitudes faced with the learning of this subject (Gal & Ginsburg, 1994; Ramirez, Schau & Emmioglu, 2008), justify the need to measure attitudes. The information on attitudes towards statistics enables identifying the students who are potentially at risk of failure and, consequently, developing a preventive intervention which will help them to pass the subject. Among the numerous instruments designed to measure the attitudes towards statistics are the *Statistics Attitudes Survey* (Roberts & Bilderback, 1980), the *Attitudes Toward Statistics* scale (Wise, 1985), the *Students´ Attitudes Toward Statistics* scale (Sutarso, 1992), the *Survey of Attitudes Toward Statistics* (Schau, Stevens, Dauphinee, & Del Vecchio, 1995; Schau, 2003) and the *Students' Attitudes Toward Statistics and Technology Scale* (Anastasiadou, 2011). The first instrument created for the Spanish context was Auzmendi's (1991) *Scale of Attitudes towards Statistics*, although a clear trend followed by the researchers in this field has been the use of versions in Spanish of the scales generated in the Anglo-Saxon area, as is reflected in the reviews done by Carmona (2004) and Blanco (2008).

Of all the instruments mentioned, probably the one most used during the last two decades has been Schau et al.'s (1995) *Survey of Attitudes Toward Statistics* (SATS). Its first version had 28 items or statements which were answered using a 7-point Likert-type scale which go from strongly disagree to strongly agree. Its construction was based on a multidimensional concept of the attitudes towards statistics which includes four factors referring to affect (six items referring to positive or negative feelings towards statistics), cognitive competence (six items about students' perceptions of their knowledge and skills to learn statistics), value (nine items which allude to perceptions about the usefulness, relevance and value of statistics in personal and professional life) and difficulty (seven items referring to considerations about the difficulty which statistics entail as a subject). Later, a 36-item version (Schau, 2003) was designed, adding the factors effort (perception of the work invested in learning statistics) and interest (the student's level of interest in statistics), with four items each. Schau and Emmioğlu (2012) have informed about the scale's reliability, which has appropriate Cronbach's α values: affect (.81), cognitive competence (.84), value (.87), difficulty (.76), interest (.89) and effort (.81).

The two new factors added in the 28-item version correspond to new components of the value expectations model that Wigfield and Eccles (2000) propose to explain motivation towards performance, and which was adapted to the statistics domain and used as the basis in constructing the SATS. Its authors offer two modalities, pre-test and post-test, for both the 28-item version and the 36-item version, applicable to the beginning and the end of a course on statistics, respectively. For the two modalities, the items present a similar content and are basically differentiated by the verbal tense used.

The SATS has been used to measure the attitudes of students towards statistics in numerous contexts, including secondary education, different university degrees and different countries. Part of the studies developed have confirmed the structure proposed by its authors, both for the SATS-28 (Bechrakis, Gialamas, & Barkatsas, 2011; Chiesi & Primi, 2009; Dauphinee, Schau, & Stevens, 1997; Hilton, Schau, & Olsen, 2004) and for the SATS-36 (Carillo et al. 2016; Coetzee & Merwe, 2010; Stanisavljevic, Trajkovic, Marinkovic, Bukumiric, Cirkovic, & Millic, 2014; Tempelaar, Schim, & Gijselaers, 2007). However, Nolan, Beran and Hecker (2012), reviewing the psychometric characteristics found in different applications of fifteen instruments used for measuring attitudes towards statistics, conclude that the structure of both versions of the SATS turn out to be somewhat conflictive, in part due to the moderate or high correlations between the subscales. Another problem is found in the confirmatory analyses carried out in the works which empirically support the structure of the SATS having resorted to parcelling within each factor, following the procedure used by Schau et al. (1995). Using exploratory factor analysis (henceforth EFA) and considering the individual items, Cashin and Elmore (2005) noted two dimensions in the SATS-28 by grouping together the affect, cognitive competence and difficulty factors in a sole dimension. With the same methodology, for a Spanish version of this instrument, Estrada (2007) obtained a five-factor solution in which a clear grouping was observed for the value factor, while the items related to affect, cognitive competence and difficulty appear mixed in the four remaining factors.

As to the SATS-36, the discrepancies which different authors have found with the factor structure proposed are notorious, particularly when using individual items instead of groups or when developing adaptations to other contexts. VanHoof, Kuppens, Castro, Verschaffel and Onghena (2011) applied this instrument to Belgian universities, finding that the six-factor structure could be reduced to four, after eliminating some items which functioned badly and again combining the subscales affect, cognitive competence and difficulty into a sole factor. On the other hand, Khavenson, Orel and Tryakshina (2012), via EFA, found seven factors by applying a Russian adaptation of the SATS-36 aimed at university students, with a definition of factors and distribution of items which presented differences with respect to the original structure. In their final proposal of a Russian version of the instrument, they excluded the seventh factor due to it only including two items and recorded a low index of reliability measured by Cronbach’s alpha. Nor has the structure of the SATS-36 been confirmed when applying it to a population of Pakistani university students (Ashrafi & Tariq, 2015). Recently, Hommik and Luik (2017) have adopted the instrument for its use with secondary education Estonian students. The lack of fit in the original six-factor model has led these authors to eliminate nine items which functioned badly and to propose a four-factor structure which has turned out to be more appropriate in terms of reliability and validity.

Although the SATS-36 has been applied to samples of students of distinct areas of university teaching in very diverse countries and its technical characteristics have been analysed, we have not found in the literature any validation study to be used with Spanish students. The aim of this work is to check the psychometric properties, in terms of structural validity and internal consistence, of the Spanish version of the SATS-36 when it is applied in Education Sciences. For their students, statistics tend to be a difficult academic subject. It is interesting to measure the attitudes towards statistics in this group when considering the teaching and the learning of statistics contents. Consequently, with this work we aim to propose a valid instrument to measure attitudes towards statistics in the Spanish university context, particularly in the area of Education Sciences.

Method

Participants

A total of 409 students (55 men and 354 women) of the University of Seville have taken part in the study, belonging to three cohorts of students who study an introduction to statistics in the study plan of the Degree of Pedagogy. Assuming that there are not reasons to suspect that the students' attitudes towards statistics differ significantly in accordance with the university in which they study Education Sciences, the participant sample has been taken from the University of Seville for reasons of accessibility. The participants are aged between 19 and 54 years old, though 72.9% are not more than 23 years old. Their previous experience in statistics is varied, taking into account the A-level modalities previously studied: 2.4% studied Arts, 68.5% Humanities and Social Sciences, 3.2% Technology, 19.6% Nature and Health Sciences and 6.4% have not studied A-levels, having accessed university via other ways, such as Vocational Training or tests for those over 25 years old. Given the diversity of the previous academic paths, the number of subjects of a mathematical or statistic content studied before varies between 0 and 5, though 57.8% of the participants have studied a maximum of one subject and 91.6% did not study more than two.

Instrument

The Spanish version of the SATS-36 is constructed starting out from that which was already used for the SATS-28 in the work of Estrada (2007). The eight items added were translated by the authors and then submitted to the review of a professional translator. A first draft of the 36 items was submitted to the consideration of various students, with a view to identifying possible ambiguities or formulations which are difficult to understand. This led to introducing adjustments in the instrument's final version (see https://goo.gl/3oVUpN).

The SATS-36 was administered to the participants at the beginning of the subject, which is studied in the second year of studies corresponding to the Degree in Pedagogy and is temporarily placed in the second term of the academic year. The data collection took place in February 2016 (152 students), 2017 (166 students) and 2018 (91 students). The scale was answered in the first class session, before presenting the subject and making the teaching programme proposed for it known. Thus, the attitudes of the students are not influenced by the experience acquired during the process of learning the subject.

Data analysis

The answers obtained for each item of the SATS-36 express the degree of agreement with its statement, with values from 1 to 7. For the analysis, the answers for the 19 items with negative statements were codified inversely, so that the maximum agreement with the item was assigned the value 1 instead of 7. In this way, the positive attitudes towards statistics correspond with the highest scores in the items.

The confirmatory factor analysis (henceforth, CFA) of the six-factor structure, defended by the authors of the instrument, gave low goodness of fit levels of the model. The authors of this work therefore decided to propose a new model. To do so, first an EFA by principal components and varimax rotation was carried out. Taking into account that the variables generally have high commonalities, the principal components method enables obtaining unbiased estimators. To check the EFA's factor structure, a CFA was carried out, using the maximum verisimilitude method. Finally, we have used the values of Cronbach's α and McDonald's Ω to estimate the reliability of each of the dimensions considered.

For all the analyses the SPSS software and AMOS version 24 have been used, except in the case of the coefficient of McDonald's Ω, calculated from Excel.

Results

Exploratory analysis

The matrix of correlations between items has been valued to ensure the reliability of the factor analysis. Bartlett's test of sphericity (χ^2 = 5008.800; gl = 435; p<.000) allows it to be stated that this matrix is an identity matrix, while the Kaiser-Meyer-Olkin measurement of sampling appropriateness attains a high value (KMO = .875). Both results indicate that the extraction of factors from the matrix of correlations observed is possible.

Following the usual criterion of retaining factors whose self-value is at least the unit, the EFA permits setting a five-factor structure (Affect-competence, Value, Difficulty, Interest, Effort). Six items were previously eliminated (3, 6, 8, 10, 11 and 31) as they either did not present an appropriate level of saturation (r > .40) in any of the factors, or saturated with a high level in more than one of them. This structure explains 56.12% of the total variance. The percentage of variance explained would be lower eliminating only some of the six items mentioned. Table 1 shows the distribution of items for each of the five factors identified.

Table 1 - *Matrix of rotated components for the items of the scale*

	Components				
	Interest	Affect-competence	Value	Effort	Difficulty
20. I am interested in using statistics	**.789**	.164	.318	.132	.027
19. I will enjoy taking statistics courses	**.696**	.273	.043	.061	.068
29. I am interested in learning statistics	**.666**	.136	.186	.286	-.075
23. I am interested in understanding statistical information	**.644**	.182	.144	.272	-.201
12. I am interested in being able to communicate statistical information to others	**.636**	.095	.220	.032	-.040
17. I use statistics in my everyday life	**.558**	.003	.182	-.125	.102
5. I will have trouble understanding statistics because of how I think	.028	**.769**	.109	.029	-.056
4. I will feel insecure when I have to do statistics problems	.023	**.668**	.118	-.069	-.011
15. I will get frustrated going over statistics tests in class	.041	**.647**	.255	-.052	.038
28. I am scared by statistics	.253	**.631**	.116	-.219	.259
35. I will find it difficult to understand statistical concepts	.253	**.608**	.053	.012	.420
26. I will make a lot of math errors in statistics	.108	**.606**	.013	.139	.293
18. I will be under stress during statistics class	.267	**.564**	.204	-.062	.259
32. I will understand statistics equations	.310	**.541**	.048	.151	-.100
13. Statistics is not useful to the typical professional	.136	.122	**.737**	.001	-.022
25. I will have no application for statistics in my profession	.131	.038	**.717**	.062	-.080
21. Statistics conclusions are rarely presented in everyday life	.136	.111	**.685**	.010	.196
33. Statistics is irrelevant in my life	.349	.162	**.639**	.092	.182
7. Statistics is worthless	.018	.248	**.596**	.112	-.078
16. Statistical thinking is not applicable in my life outside my job	.375	.086	**.590**	-.054	.131
9. Statistics should be a required part of my professional training	.364	.132	**.480**	.191	-.176
2. I plan to work hard in my statistics course	.106	-.017	.058	**.827**	.019
14. I plan to study hard for every statistics test	.151	-.032	-.018	**.721**	-.061
27. I plan to attend every statistics class session	-.007	.004	-.001	**.671**	-.109
1. I plan to complete all of my statistics assignments	.068	.003	.207	**.643**	-.100
34. Statistics is highly technical	.030	-.038	-.097	-.043	**.728**
24. Learning statistics requires a great deal of discipline	-.044	.080	.065	-.285	**.614**

36. Most people have to learn a new way of thinking to do statistics	-.123	.077	.077	-.024	**.551**
30. Statistics involves massive computations	-.069	.202	.102	.047	**.511**
22. Statistics is a subject quickly learned by most people	.291	.059	-.110	-.121	**.468**

Confirmatory analysis

To comparatively value the results obtained by considering five factors, a first model is proposed which coincides with the six-factor structure defended by the authors of the SATS-36. The second model includes the five components, considering that each item loads uniquely on one latent variable, that the factors covary and that the terms of error are not co-related. A third model includes, along with the five common factors, the correlations between errors (CE), although only for the five pairs of items which present the highest modification indices (4-5, 9-33, 19-20, 19-23 and 23-29).

Figure 1 graphically shows the final model's structure (five CE factors).

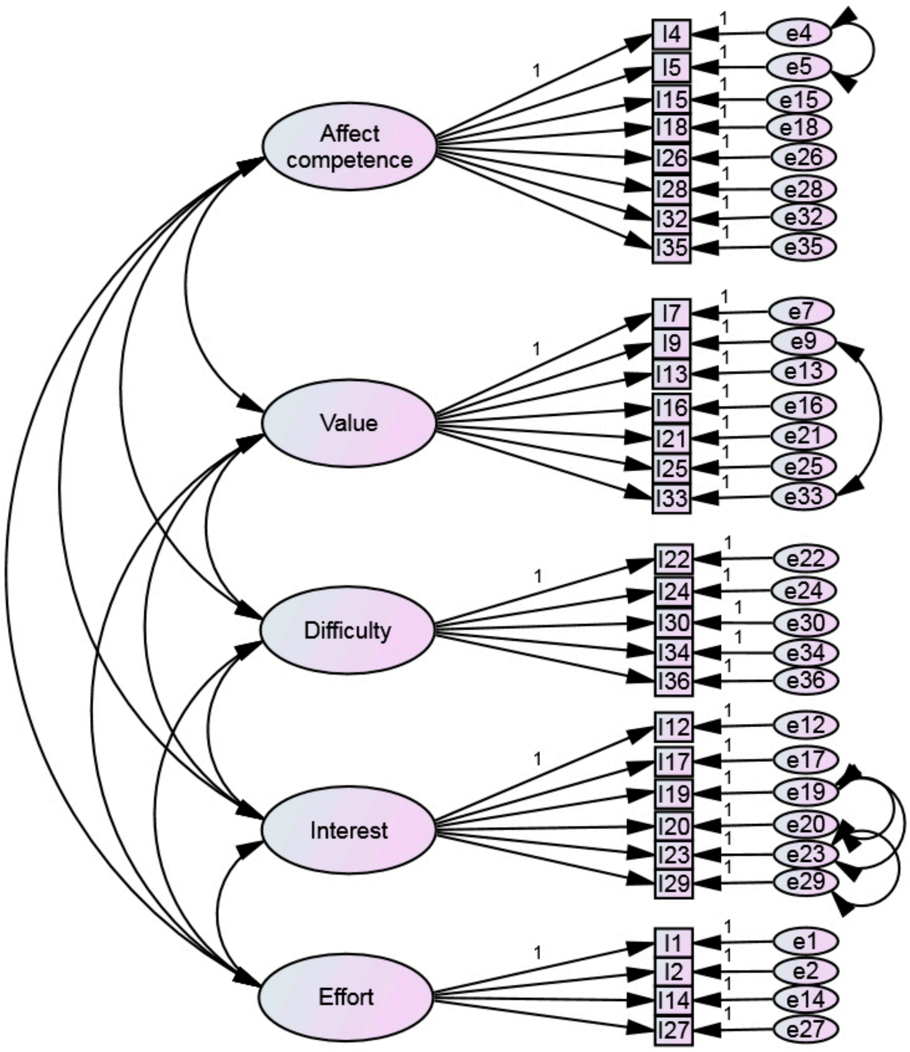

Figure 1. Factor model for the SATS

Addressing the modification indices, the significance of the parameters corresponding to covariances between unique factors is valued. To value the goodness of fit of each of the three models, we have considered, taking as a reference Boomsma (2000), Hu and Bentler (1999), Marsh, Hau, and Wen, (2004) and Ntoumanis, (2001), the reason between χ^2 and the degree of freedom, the comparative fit index (CFI), the goodness of fit index (GFI), the Root Mean Square Error (RMR) and the Root Mean Square Error of Approximation (RMSEA). These are considered acceptable when χ2/d.f. is less than 5, the CFI and GFI indexes are over .85 (the ideal is to be above .90) and the error indexes (RMR and RMSEA) are below .07 (although the ideal would be under .05).

The results shown in Table 2 indicate a lack of fit for the six-factor model proposed by the authors of the SATS-36. Basing ourselves on the criteria mentioned before, the goodness of fit is significantly better for the final five-factor model with CE. In this model, the reason between χ^2 and the degrees of freedom is 2.19, a value which does not surpass the limit of 3 and therefore means a good fit between the model proposed and the data observed. On the other hand, this index surpasses the threshold of 3 in the case of the original model. As to the comparative fit index (CFI) and the goodness of fit index (GFI), the best approximations to the quota of .900 are obtained in the final model, a value from which an optimum fit level can be considered. The RMR value, although it is not maintained below .050, presents a better performance in the five-factor model with CE than in the other two models. Furthermore, in the final model the Root Mean Square Error of Approximation (RMSEA) is very appropriate, as it is around .050.

Table 2 - *Goodness of fit indexes for the factor models*

Model	χ^2/d.f.	CFI	GFI	RMR	RMSEA (IC 90%)
Original model	3.02	.767	.770	.142	.070 (.067-.074)
Five factors	2.42	.854	.860	.117	.059 (.054-.064)
Five factors with CE	2.19	.878	.873	.115	.055 (.049-.059)

Nota: CFI = Comparative Fit Index; GFI = Goodness of Fit Index; RMR = Root Mean square Residual; RMSEA = Root Mean Square Error of Approximation

The standardised correlation coefficients between factors and between variables and factors have also been studied. The objective is to confirm, on the one hand, the validity of the construct of the instrument and, on the other hand, its discriminant validity, paying special attention, in this latter case, to the correlation between the latent variables, attenuated by the measurement error (+/- 2 times the measurement error), being less than the unit. Most of the factor loadings of each variable attain high values (R>.6). They are all statistically significant, having p<.01. The lowest loading corresponds to item 22 (*Statistics is a subject that most people learn quickly)*, with .406 in the subscale *Difficulty*. The highest is .865, which is recorded for item 20 (*I am interested in using statistics*) in the subscale *Interest*. The results obtained therefore support the five-factor structure proposed for the instrument.

The inexistence of correlations between factors close to the unit (see Table 3), makes us rule out that two factors really represent the same dimension. This endorses the discriminant validity of the model, which presents sufficiently differentiated dimensions.

Table 3 - *Matrix of correlations between factors and between items and factors*

	Interest	Difficulty	Value	Effort	Affect-competence
Interest	1.000				
Difficulty	.019	1.000			
Value	.663	.060	1.000		
Effort	.325	-.371	.262	1.000	
Affect_competence	.440	.561	.457	-.011	1.000
I19	**.640**	.012	.424	.208	.282
I7	.321	.029	**.484**	.127	.221
I33	.490	.044	**.739**	.194	.337
I25	.413	.037	**.623**	.163	.284
I13	.428	.039	**.645**	.169	.294
I9	.404	.036	**.609**	.160	.278
I17	**.416**	.008	.276	.135	.183
I12	**.608**	.012	.404	.197	.268
I35	.331	.422	.343	-.008	**.752**
I32	.205	.261	.213	-.005	**.466**
I28	.322	.410	.334	-.008	**.731**
I26	.296	.377	.307	-.007	**.672**
I27	.181	-.206	.146	**.557**	-.006
I14	.197	-.225	.159	**.608**	-.006
I2	.263	-.301	.213	**.811**	-.009
I1	.233	-.266	.188	**.717**	-.008
I29	**.629**	.012	.417	.204	.277
I23	**.641**	.012	.425	.208	.282
I20	**.865**	.017	.574	.281	.381
I36	.008	**.427**	.026	-.158	.240
I34	.010	**.499**	.030	-.185	.280
I30	.009	**.453**	.027	-.168	.254
I24	.012	**.621**	.037	-.230	.348
I22	.008	**.406**	.024	-.150	.228
I21	.387	.035	**.584**	.153	.267
I16	.397	.036	**.598**	.157	.273
I18	.318	.405	.330	-.008	**.723**
I15	.256	.326	.266	-.006	**.582**
I5	.242	.309	.251	-.006	**.550**
I4	.207	.264	.215	-.005	**.470**

Reliability

The reliability of the instrument (see Table 4), estimated from Cronbach's α, is good (α >.80) for the dimensions "Affect-competence" and "Value" and acceptable (α > .70) for "Difficulty", "Interest" and "Effort", in accordance with the criteria proposed by George and Mallery (2003). As to McDonald's Ω, the values obtained may be considered more than acceptable. They attain or surpass .80, with the unique exception of the dimension "Difficulty", which is .73.

Table 4 - *Calculation of reliability in each factor*

Subscales	Cronbach's α	McDonald´s Ω
Affect-competence	.81	.83
Value	.86	.88
Difficulty	.72	.73
Interest	.79	.84
Effort	.76	.80

Discussion and conclusions

The aim of our study has been to value the psychometric properties of the SATS-36 when applied to a sample of Spanish students of Education Sciences, with the ultimate aim of proposing a version adapted to this group. When analysing the instrument, we have considered each of the items, without resorting to the item parcelling proposed by Schau et al. (1995) for the analysis of the structure of the SATS-28 and later used in works which have confirmed an underlying six-factor structure for the SATS-36 (Carillo et al., 2016; Coetzee & Merwe, 2010; Tempelaar et al., 2007). Item parcelling consists of forming groups of 3 or 4 items within each dimension, considering in the exploratory or confirmatory factor analyses the sum or the average scores in these groups instead of the individual scores. The aim is to reduce problems of normality in certain items and improve the reliability. However, this procedure has caused controversy (Bandalos & Finney, 2001), particularly because it is assumed that the items grouped in parcels measure the same dimension, which cannot be assumed without a prior verification. By opting for the use of individual items and not parcelled items, in this work we obtain results which to a certain extent deviate from the original structure of the instrument. Yet, the analysis of the individual items enables access to the true structure of the set of items which make up the SATS-36, avoiding the biases derived from item parceling (VanHoof et al., 2011).

After the analyses carried out, we have removed items which functioned inappropriately, resulting in a model of 30 items grouped into 5 factors, which mean the integration of the subscales *affect* and *cognitive competence* in a sole factor. This model is preferable for the Spanish version, given that it presents more appropriate goodness of fit measurements than those obtained when considering the original structure of 36 items in 6 factors. One conclusion of this work is, therefore, that with a more parsimonious model of 5 factors the inter-relations observed between the items of the instrument are described appropriately. The items included in four of the dimensions of the model *-value, difficulty, interest* and *effort-* practically coincide with those proposed by Schau (2003) for the SATS-36. The only exception is the absence of the items removed and the presence in the *interest* dimension of items 17 and 19, coming from, respectively, the dimensions *value* and *affect* in the original structure. The main modification manifests itself in the grouping of the factors *affect* and *cognitive competence* in a sole dimension, in which 8 items remain included, of which half come from the dimension *affect* and the other half from the dimension *cognitive competence*.

This result aligns with the reduction of the number of attitudinal components measured with the SATS, already noted in previous works which considered individual items and not parceled items. A reiterated result has been the grouping of the subscales *affect*, *cognitive competence* and *difficulty*, which was found in the works of VanHoof et al. (2011), with an adaptation of the SATS-36, and of Cashin and Elmore (2005), using the SATS-28. Behind this grouping is the existence of correlations between the referred subscales, as suggested by Nolan et al. (2012) to explain the discrepancies regarding the original structure of the instrument. In fact, the correlation between the factors *affect* and *cognitive competence* has managed to surpass 0.90 in different studies which analysed the structure of the SATS-28 (Dauphinee et al., 1997; Hilton et al., 2004; Schau et al., 1995) and 0.80 in others focused on the SATS-36 (Tempelaar et al., 2007; VanHoof et al., 2011). In the Spanish version applied in our study, the reduction of subscales has been illustrated in the grouping of the factors *affect* and *cognitive competence*; *difficulty* remaining as a differentiated component of the attitudes towards statistics. The correlations between these 5 factors attain values below 0.67.

As to the reliability measured by Cronbach's α and McDonald's Ω, the 5 factors found for the Spanish adaptation of the SATS-36 present values between .72 and .88. These indexes reflect in general a good level of internal consistence for the subscales, taking into account that the number of items is relatively low in some of them. In this same line, authors such as Tempelaar et al. (2007) and Carillo et al. (2016) obtained values of reliability between .76 and .83 in the original six-factor model, with the exception of the dimension *difficulty*, which has values of α=.68 and α=.59, respectively, in both works.

According to the psychometric properties of the Spanish adaptation of the SATS-36, we can state that the proposed instrument is appropriate for the measurement of attitudes towards statistics in Spanish university students who study Education Sciences. Having an instrument to measure the attitudes towards statistics has an undeniable interest from the point of view of teaching and learning this subject. Bearing in mind the relation between the attitudes and the achievements in terms of learning, the prior diagnosis of the attitudes of the students who are ready to begin a course of statistics allows orienting the teaching process and detecting students who have a greater risk of failure or dropout. In this sense, the multidimensional character of the attitudes construct provides differentiated information on which to base the teachers' intervention.

The situation observed in relation to each of the dimensions measured in the attitudes construct will enable putting into practice a pedagogical approach adapted to the students (Carillo et al., 2016). Thus, for example, if the attitudinal deficits are materialised in negative feelings (affect-competence dimension), it will be appropriate to foster a ludic approach able to make the subject attractive. If the students do not appreciate the usefulness of statistics (dimension value), it will be necessary to insist on the importance of this instrument in the work environment, resorting, for example, to the testimony of professionals or, in daily life, showing for instance statistics on current topics which have appeared in the media. Facing perceptions that statistics are complex and require the use of complicated formulas (difficulty dimension), the teaching will have to graduate the presentation of the contents, beginning with levels which are easily accessible for the students and prioritise the use of computer tools which free students from the manual application of formula-based calculations.

The availability of an instrument validated for the diagnosis of the attitudes towards statistics in university students also represents a contribution for teaching and for the development of research concerning this field in the Spanish context. The SATS-36 will be able to incorporate the repertory of instruments available in Spanish (Blanco, 2008; Carmona, 2004), facilitating the work of the researchers interested in topics such as, for example, the influence of the different methods of teaching statistics on attitudes, or the relation between attitudes and academic performance. Furthermore, the teachers will count on one tool more to identify negative attitudes in their students and start up interventions aimed at improving them, and in this way contribute to learning.

Nevertheless, our study has limitations which must be taken into account. The sample used, despite being large, is homogeneous and is confined to a specific academic context, as it is a question of students who study Pedagogy. Consequently, the conclusions drawn are to be viewed with caution when generalising them. For this reason, it is recommended to carry out new studies with samples of students of other degrees. This would enable checking the invariance of the structure proposed here for the components of attitudes towards statistics measured with the SATS. On the other hand, the structure found for the pre-test version of the SATS could be the subject of confirmation in the case of the post-test version used to measure the attitudes of the students after having done a statistics course. Lastly, the removal of items which have functioned inappropriately, reducing the scale to 30 elements, merits a more detailed analysis. In this sense, the drafting of some of these items in the original version could be revised, making use of the students' valuation of their content to identify possible ambiguities or difficulties of interpretation which would explain the problem. This would allow analysing the psychometric properties of a revised version of the SATS-36, applying it before or after doing a subject which has a content of statistics.

References

Anastasiadou, S. D. (2011). Reliability and validity testing of a new scale for measuring attitudes toward learning statistics with technology. *Acta Didactica Napocensia*, *4*(1), 1–10.

Ashrafi, G. M., & Tariq, M. I. (2015). Investigating discrepancies in reliability coefficient of survey of students' attitudes towards statistics (SATS 36) for a Pakistani sample. *International Interdisciplinary Journal of Education*, *4*(7), 201-225. doi: https://doi.org/10.12816/0025212

Auzmendi, E. (1991). *Factors related to attitudes toward statistics: A study with a Spanish sample.* Paper presented at the annual meeting of the American Educational Research Association, Chicago.

Bandalos, D. L., & Finney, S. J. (2001). Item parceling issues in structural equation modeling. In G. A. Marcoulides and Schumacker, R. E. (Eds.), *New Developments and Techniques in Structural Equation Modeling* (chap. 10, 269-296), Hillsdale, N.J.: Lawrence Erlbaum Associates.

Bechrakis, T., Gialamas, V., & Barkatsas, A. N. (2011). *Survey of Attitudes Toward Statistics* (SATS): An investigation of its construct validity and its factor structure invariance by gender. *International Journal of Theoretical Educational Practice*, *1*(1), 1–15.

Blanco, A. (2008). Una revisión crítica de la investigación sobre las actitudes de los estudiantes universitarios hacia la estadística. *Revista Complutense de Educación*, *19*(2), 311-330.

Bollen, K. A. (1989). Structural equations with latent variables. New York: Wiley. doi: https://doi.org/10.1002/9781118619179

Boomsma, A. (2000). Reporting Analyses of Covariance Structures. *Structural Equation Modeling: A Multidisciplinary Journal*, *7*(3), 461–483. doi: https://doi.org/10.1207/S15328007SEM0703_6

Bourne, V. J. (2018). Exploring Statistics Anxiety: Contrasting Mathematical, Academic Performance and Trait Psychological Predictors. *Psychology Teaching Review*, *24*(1), 35-43.

Carillo, K., Galy, N., Guthrie,C., & Vanhems, A. (2016). «J'aime pas les stats!» – Mesure et analyse de l'attitude à l'égard du cours de statistique dans une école de management. *Statistique et enseignement*, *7*(1), 3-31.

Carmona, J. (2004). Una revisión de las evidencias de fiabilidad y validez de los cuestionarios de actitudes y ansiedad hacia la estadística. *Statistics Education Research Journal*, *3*(1), 5-28.

Carmona, J., Martínez R.J. & Sánchez, M. (2005). Mathematical background and attitudes toward statistics in a sample of Spanish college students. *Psychological Reports*, *97*(1), 53-62. doi: https://doi.org/10.2466/pr0.97.1.53-62

Cashin, S. E., & Elmore, P. B. (2005). The Survey of Attitudes Toward Statistics Scale: a construct validity study. *Educational and Psychological Measurement*, *65*(3), 509-524. doi: https://doi.org/10.1177/0013164404272488

Chiesi, F., & Primi, C. (2009). Assessing statistics attitudes among college students: Psychometric properties of the Italian version of the Survey of Attitudes toward Statistics (SATS). *Learning and Individual Differences*, *19*(2), 309-313. doi: https://doi.org/10.1016/j.lindif.2008.10.008

Chiesi, F., & Primi, C. (2010). Cognitive and non-cognitive factors related to students statistics achievement. *Statistics Education Research Journal*, *9*(1), 6–26. Retrieved from http://www.stat.auckland.ac.nz/~iase/serj/SERJ9%281%29_Chiesi_Primi.pdf

Coetzee, S., & Merwe, P. V. D. (2010). Industrial psychology students' attitudes towards statistics. *SA Journal of Industrial Psychology*, *36*, 1–8. doi: https://doi.org/10.4102/sajip.v36i1.843

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, N.J.: Lawrence Erlbaum.

Comas, C., Martins, J., Nascimento, M.M. & Estrada, A. (2017). Estudio de las actitudes hacia la estadística en estudiantes de Psicología. *Bolema: Boletim de Educação Matemática*, *31*(57), 479-496. doi: https://doi.org/10.1590/1980-4415v31n57a23

Dauphinee, T. L., Schau, C., & Stevens, J. J. (1997). *Survey of Attitudes Toward Statistics*: Factor structure and factorial invariance for women and men. *Structural Equation Modeling*, *4*(2), 129–141. doi: https://doi.org/10.1080/10705519709540066

Estrada, A. (2002). *Análisis de las actitudes y conocimientos estadísticos elementales en la formación del profesorado*. Tesis doctoral. Universidad Autónoma de Barcelona

Estrada, A. (2007). Actitudes hacia la estadística: un estudio con profesores de Educación Primaria en formación y en ejercicio. En M. Camacho, P. Flores y P. Bolea (Eds.), *Investigación en Educación Matemática XI* (pp. 121-140). La Laguna: SEIEM.

Gal, I., & Ginsburg, L. (1994). The role of beliefs and attitudes in learning statistics: towards an assessment framework. *Journal of Statistics Education*, *2*(2). doi: https://doi.org/10.1080/10691898.1994.11910471

George, D., & Mallery, P. (2003). SPSS for Windows step by step: A simple guide and reference. 11.0 update. Boston: Allyn & Bacon.

Haladyna, T., & Shaughnessy, J. (1982), Attitudes toward science: A quantitative synthesis. *Science Education*, *66*, 547–563. doi: https://doi.org/10.1002/sce.3730660406

Hilton, S. C., Schau, C., & Olsen, J. A. (2004). Survey of Attitudes Toward Statistics: Factor structure invariance by gender and by administration time. *Structural Equation Modeling*, *11*(1), 92–109. doi: https://doi.org/10.1207/S15328007SEM1101_7

Hommik, C., & Luik, P. (2017). Adapting the survey of attitudes toward statistics (SATS-36) for Estonian secondary school students. *Statistics Education Research Journal*, *16*(1), 228-239.

Hood, M., Creed, P. A., & Neumann, D. L. (2012). Using the expectancy value model of motivation to understand the relationship between student attitudes and achievement in statistics. *Statistics Education Research Journal*, *11*, 72-85.

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal*, *6*(1), 1-55. doi: https://doi.org/10.1080/10705519909540118

Khavenson, T., Orel, E., & Tryakshina, M. (2012). Adaptation of survey of attitudes towards estatistics (SATS 36) for Russian sample. *Procedia-Social and Behavioral Sciences*, *46*, 2126-2129. doi: https://doi.org/10.1016/j.sbspro.2012.05.440

Ma, X., & Kishor, N. (1997). Assessing the Relationship between Attitude toward Mathematics and Achievement in Mathematics: A Meta-Analysis. *Journal for Research in Mathematics Education*, *28*(1), 26-47. doi: https://doi.org/10.2307/749662

Marsh, H. W., Hau, K. T., & Wen, Z. (2004). In search of golden rules: Comment on hypothesis testing approaches to setting cutoff values for fit indexes and dangers in overgeneralizing Hu & Bentler's (1999) findings. *Structural Equation Modeling*, *11*, 320-341. doi: https://doi.org/10.1207/s15328007sem1103_2

Mills, J. D. (2004). Students' attitudes toward statistics: implications for the future. *College Student Journal*. *38*(3), 349-361.

Nolan, M. M., Beran, T., & Hecker, K. G. (2012). Surveys assessing students' attitudes toward statistics: A systematic review of validity and reliability. *Statistics Education Research Journal, 11(2), 103-123*. Retrieved from http://iase-web.org/documents/SERJ/SERJ11(2)_Nolan.pdf

Ntoumanis, N. (2001). A self-determination approach to the understying of motivation in physical education. *British Journal of Educational Psychology*, *71*, 225-242. doi: https://doi.org/10.1348/000709901158497

Onwuegbuzie, A. (2000). Attitudes toward statistics assessment. Assessment & Evaluation in Higher Education, *25*(4). 321-339. doi: https://doi.org/10.1080/713611437

Onwuegbuzie, A.J., & Wilson, V.A. (2003). Statistics Anxiety: nature, etiology, antecedents, effects, and treatments - a comprehensive review of the literature. *Teaching in Higher Education*, *8*, 195-209

Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: a review of the literature and its implications. *International Journal of Science Education*, *25*(9), 1049-1079. doi: https://doi.org/10.1080/0950069032000032199

Peters, P., Smith, A., Middledorp, J., Karpin, A., Sin, S., & Kilgore, A. (2013). Learning essential terms and concepts in statistics and accounting. *Higher Education Research & Development*, *33*(4), 742-756. doi: https://doi.org/10.1080/07294360.2013.863838

Ramirez, C., Schau, C., & Emmioglu, E. (2008). The importance of attitudes in statistics education. *Statistics Education Research Journal*, *11*(2), 57-71.

Roberts, D. M., & Bilderback, E. W. (1980). Reliability and validity of a statistics attitudes survey. *Educational and Psychological Measurement*, *40*, 235-238. doi: https://doi.org/10.1177/001316448004000138

Ruiz de Miguel, C. (2015). Actitudes hacia la estadística de los alumnos del Grado en Pedagogía, Educación Social y Maestro de Educación Primaria en la UCM. *Educación XX1*, *18*(2), 351-374. doi: https://doi.org/10.5944/educxx1.12158

Schau, C. (2003). *Survey of Attitudes Toward Statistics* (SATS-36). Retrieved from http://evaluationandstatistics.com/

Schau, C., Stevens, J., Dauphinee, T., & Del Vecchio, A. (1995). The development and validation of the *Survey of Attitudes Toward Statistics*. *Educational and Psychological Measurement*, *55*(5), 868–875. doi: https://doi.org/10.1177/0013164495055005022

Sesé, A., Jiménez, R., Montaño, J. J., & Palmer, A. (2015). ¿Pueden las actitudes hacia la estadística y la ansiedad estadística explicar el rendimiento de los estudiantes? *Revista de Psicodidáctica*, *20*(2), 285-304. doi: https://doi.org/10.1387/RevPsicodidact.13080

Stanisavljevic, D., Trajkovic, G., Marinkovic, J., Bukumiric, Z., Cirkovic, A., & Millic, N. (2014). Assessing Attitudes towards Statistics among Medical Students: Psychometric Properties of the Serbian Version of the Survey of Attitudes Towards Statistics (SATS). *PLoS ONE*, *9*(11): e112567. doi: https://doi.org/10.1371/journal.pone.0112567

Sulieman, H. (2015). Students' conceptions of statistics: an exploration of attitudes across majors. *International Research in Education*, *3*(2), 158-172. doi: https://doi.org/10.5296/ire.v3i2.7622

Sutarso, T. (1992). *Some variables in relation to students´anxiety in learning statistics*. Paper presented at the Annual Meeting of the Mid-South Educational Research Association, Knoxville.

Tempelaar, D. T., Schim, S., & Gijselaers, W. H. (2007). A structural equation model analyzing the relationship of students' attitudes toward statistics, prior reasoning abilities and course performance. *Statistics Education Research Journal*, *6*(2), 78–102. Retrieved from http://www.stat.auckland.ac.nz/~iase/serj/SERJ6%282%29_Tempelaar.pdf

VanHoof, S., Kuppens, S., Castro Sotos, A. E., Verschaffel, L., & Onghena, P. (2011). Measuring statistics attitudes: Structure of the Survey of Attitudes Toward Statistics (SATS-36). *Statistics Education Research Journal*, *10*(1), 35-51. Retrieved from http://iase-web.org/documents/SERJ/SERJ10(1)_Vanhoof.pdf

Vilá, R, & Rubio, M. J. (2016). Actitudes hacia la Estadística en el alumnado del grado de Pedagogía de la Universidad de Barcelona. *REDU. Revista de Docencia Universitaria*, *14*(1), 131-150. doi: https://doi.org/10.4995/redu.2016.5766

Walker, E. R., & Brakke, K. E. (2017). Undergraduate psychology students' efficacy and attitudes across introductory and advanced statistics courses. *Scholarship of Teaching and Learning in Psychology*, *3*(2), 132-140. doi: https://doi.org/10.1037/stl0000088

Waters, L. K., Martelli, T. A., Zakrajsek, T., & Popovich, P. M. (1988). Attitudes toward statistics: an evaluation of multiple measures. *Educational and Psychological Measurement*, *45*(2), 401-405.

Wigfield, A., & Eccles, J. S. (2000). Expectancy-value theory of achievement motivation. *Contemporary Educational Psychology*, *25*(1), 68-81. doi: https://doi.org/10.1006/ceps.1999.1015

Wise, S. L. (1985). The development and validation of a scale measuring attitudes toward statistics. *Educational and Psychological Measurement*, *45*, 401-405. doi: https://doi.org/10.1177/0013164485045002 26

Acknowledgement

The authors wish to thank Candace Schau for her authorisation for the use of the SATS-36 scale and the information on the use of this instrument provided in the site http://www.evaluationandstatistics.com

Authors / Autores	To know more / Saber más
Rodríguez-Santero, Javier (jarosa@us.es). Professor in the Department of Research Methods and Diagnosis in Education, University of Seville. He teaches about research methods and quantitative and qualitative data analysis. In recent years, its scientific production has focused on topics related to large-scale performance evaluations and training processes. Postal address: Faculty of Education Sciences. C / Pirotecnia, s / n. 41013-Sevilla (Spain).	0000-0001-5727-4545
Gil-Flores, Javier (jfores@us.es). University Chair in the Department of Research Methods and Diagnosis in Education at the University of Seville. He teaches on quantitative and qualitative research methods. In recent years, its scientific production has focused on topics related to large-scale performance evaluations and university education. Postal address: Faculty of Education Sciences. C / Pirotecnia, s / n.41013-Sevilla (Spain).	0000-0003-0755-4367

Revista **EL**ectrónica de **I**nvestigación y **EV**aluación **E**ducativa
E-Journal of Educational Research, Assessment and Evaluation
[ISSN: 1134-4032]