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Konstantinos Lavidas[1], Dionysios Manesis[2], and Vasilios Gialamas[2]

1) University of Patras, Greece
2) National and Kapodistrian University of Athens, Greece

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Investigation of the Statistical Anxiety Rating Scale Psychometric Properties with a Sample of Greek Students

Konstantinos Lavidas
University of Patras

Dionysios Manesis, Vasilios Gialamas
National and Kapodistrian University of Athens

Abstract

The purpose of this study was to adapt the Statistics Anxiety Rating Scale (STARS) for a Greek student population. The STARS was administered to 890 Tertiary Education students in two Greek universities. It was performed a cross-validation study to examine the factorial structure and the psychometric properties with a series of confirmatory factor analyses. Results revealed a correlated six first-order factor model which provided the best fit to the data compared to a six-factor model with one superordinate factor. All six factors of the Greek version of the STARS presented convergent and discriminant validity and were internally consistent. Implications and limitations are discussed.

Keywords: Statistics Anxiety Rating Scale, Greek university students, cross-validation study, confirmatory factor analysis

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Propiedades Psicométricas de la Escala de Calificación de Ansiedad Estadística con una Muestra de Estudiantes Griegos

Konstantinos Lavidas
University of Patras

Dionysios Manesis, Vasilios Gialamas
National and Kapodistrian University of Athens

Resumen

El propósito de este estudio fue adaptar la Escala de Calificación de Ansiedad Estadística (STARS) para una población de estudiantes griegos. STARS se administró a 890 estudiantes de educación terciaria en dos universidades griegas. Se realizó un estudio de validación cruzada para examinar la estructura factorial y las propiedades psicométricas con una serie de análisis factoriales confirmatorios. Los resultados revelaron un modelo de seis factores de primer orden correlacionados que proporcionó el mejor ajuste a los datos en comparación con un modelo de seis factores con un factor superior. Los seis factores de la versión griega de STARS presentaron validez convergente y discriminante y fueron internamente consistentes. Se discuten las implicaciones y limitaciones.

Palabras clave: Escala de calificación de ansiedad estadística, estudiantes universitarios Griegos, estudio de validación cruzada, análisis factorial confirmatorio

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In Greek universities, like in many other universities worldwide, most students are required to enroll in at least one compulsory statistics course in many faculties such as Education and Social Sciences (Lavidas et al., 2020). Many scholars mention that the statistics course is a fundamental module in tertiary education, aiming not only to provide the necessary knowledge of statistics needed for effectively conducting quantitative research but also to further develop critical and analytic thinking skills (Ben-Zvi & Makar, 2016; Koh & Zawi, 2014; Lavidas et al., 2020; Ruggeri, Dempster & Hanna, 2011). Nevertheless, most students in social sciences do not realize the potential value of statistics in their field of studies or their future careers. Hence, attending a statistics course is often a negative and anxious experience, mainly because of the difficulties of grasping statistical concepts (Chiesi & Primi, 2010).

Statistics anxiety has been defined as the feelings of anxiety students encounter when attending a statistics course or implementing statistical methodology (Cruise, Cash & Bolton, 1985). Those feelings could include intensive worry, tension, mental disorganization, intrusive thoughts, and symptoms of stress when students enrolled in statistics courses as an integral part of their curriculum (Papousek et al., 2012; Zeidner, 1991). Literature support that the percentage of graduate students in social and behavioral sciences, psychology, and business, experiencing uncomfortable levels of statistics anxiety is between 66% and 80% (Mji & Onwuegbuzie, 2004). As a result, statistics anxiety may provoke several problems over the statistics course in college, and many times, statistics anxiety considered as a major barrier to achieving satisfactory academic performance across several academic disciplines, such as education (Nasser, 2004; Onwuegbuzie, 2004), psychology (Chiesi & Primi, 2010; Macher et al., 2012; Shah Abd Hamid & Karimi Sulaiman, 2014), and business (Bell, 2008). In this frame, it is clear that university lecturers must take into account students' statistic anxiety before lecturing. Hence, statistics teachers could measure the level of statistics anxiety of students and revise their teaching utilizing approaches that decrease the students' statistic anxiety and increase the students' engagement in the learning procedure (Lavidas et al., 2020; Williams, 2014).

A further review of the statistics and math anxiety and instruments for their measurement revealed the existence of several instruments for measuring statistics anxiety, such as the STARS (Cruise et al., 1985), the Statistics Anxiety Measure (Earp, 2007), the Statistics Anxiety Scale (Pretorius & Norman, 1992), the Statistical Anxiety Scale (Virgil-Colet, Lorenzo-Seva & Condon, 2008), and the Statistics Anxiety Inventory (Zeidner, 1991), and for measuring math anxiety, the Scale for Assessing Math Anxiety in Secondary education (SAMAS) (Yáñez-Marquina & Villardón-Gallego, 2017). However, the STARS (Cruise et al., 1985) has been used extensively worldwide by researchers due to the superiority of its validity and reliability data as compared with other measures (Chew & Dillon, 2014). For example, Virgil-Colet et al. (2008) developed a scale to assess the anxiety of students taking a statistics course, the "Statistical Anxiety Scale" (SAS). SAS was a three dimensional instrument that assessed three different aspects of anxiety. These aspects were: examination anxiety, asking for help anxiety, and interpretation anxiety. Nevertheless, at least half of the items of SAS were derived from STARS, and the analysis of the validity of the measure was insufficient. Also, another instrument was developed by Earp (2007), the "Statistics Anxiety Measure" (SAM), to measure statistics anxiety and identify students who confronted statistics anxiety in statistics courses. SAM consisted of six subscales: anxiety, fearful behavior, attitude, expectation, history, self-concept, and performance. The analysis of the factorial structure of SAM resulted in a four-factor structure (anxiety, class, math, and performance) comprised of 23 items and with a poorer internal consistency compared to STARS.

Taking into account the superiority of STARS as we mentioned before, as well as no previous attempt has been reported in Greece aiming to validate STARS for the Greek student population so far, it is very important to be carried out in this research. Therefore, this study aims to investigate the factorial structure and the psychometric properties of the STARS for a Greek student population.

Literature review

Many studies have compared the levels of statistics anxiety among several groups of students (Chew & Dillon, 2014; Rodarte-Luna & Sherry, 2008). Furthermore, Bell (2008), in a series of studies, used the Statistics Anxiety Rating Scale (STARS) (Cruise, et al., 1985) and found differences based on course length and type of student.

Additionally to statistics anxiety, several studies have investigated tertiary students' attitudes towards statistics. Statistics anxiety and attitudes toward statistics have statistically significant negative relationships (Baloglu Kocak & Zelhart., 2007; Chew & Dillon, 2015; Finney & Schraw, 2003; Perepiczka Channdler & Becerra, 2011). Student attitudes toward statistics tend to be negative, especially in social and behavioral sciences (Mills, 2004; Sarikaya et al., 2018; van Appel & Durandt, 2018; Vanhoof et al., 2011). Due to their negative attitude, students often experience a statistics course as an intimidating component that inhibits effective conceptual learning, resulting in high levels of statistics anxiety (Baloglu et al., 2007; Onwuegbuzie & Wilson, 2003; Vanhoof et al., 2011).

Factors contributing to the statistics anxiety are broad and usually are focused on three major categories of factors: dispositional, situational, and environmental (Baloglu et al., 2007; Onwuegbuzie & Wilson, 2003). Dispositional antecedents are intrapersonal factors, which include students' emotional and psychological characteristics (Baloglu et al., 2007). Dispositional factors include topics such as attitudes toward statistics, learning styles, perceived abilities at developmental stages in life, perfectionism, evaluation concern, and fear of failure (Onwuegbuzie & Wilson, 2003; Walsh & Ugumba-Agwunobi, 2002). Situational antecedents are immediate factors arising from attending a statistics course. Situational antecedents of statistics anxiety surround students and include previous and present experiences such as minimal previous statistics and math experience, delayed introduction to quantitative research methods, mental disorientation from the value of quantitative analysis, course selection conditions (e.g. required or optional), and nature of statistics courses (Baloglu et al., 2007). Environmental antecedents are interpersonal factors mainly linked to the classroom experience, which can include student's experiences with the professor, such as lack of feedback from statistics instructors (Onwuegbuzie & Wilson, 2003).

Statistics anxiety is usually linked to mathematics self-concept (Macher et al., 2011; Williams, 2014). A person's mathematics self-concept refers to the perception (perceived competence at mathematics) about his or her ability to do well in mathematics, and may also include preferences for math, confidence in learning, and using efficiently mathematics (Ma and Kishor 1997). Students with poorer mathematics self-concept, experience high levels of statistics anxiety. This, in turn, is directly related to attitudes and performance. Many studies support that mathematics self-concept and statistics anxiety are direct predictors of attitudes toward statistics, with a positive and negative relationship respectively expected (Chamberlain et al., 2015; Chiesi & Primi, 2010; Lavidas et al., 2020; Macher et al., 2012; Sesé et al., 2015; Williams, 2014). Several math-related variables have been studied connected to statistics anxiety, but math self-concept is considered as the most common attitudinal variable (Williams, 2014).

Statistics Anxiety Rating Scale

One of the most popular instruments for measuring statistical anxiety is Statistics Anxiety Rating Scale, commonly known as STARS. STARS was developed by Cruise, et al. (1985). Even though many years have passed since STARS' first publication, it retains its popularity and has been used extensively by researchers mainly due to its satisfactory psychometric properties, and the multitude of its items (Chew et al., 2018). Initially, an 89-item pilot instrument was completed by 1150 participants in the US. A PCA (Principal Component Analysis) with varimax rotation was conducted. Results indicated that the rotation of 51 items on six factors yielded a more interpretable structure. The six components of statistics anxiety are (a) Interpretation Anxiety, (b) Test and Class Anxiety, (c) Fear of Asking for Help, (d) Worth of Statistics, (e) Computation Self-Concept, and (f) Fear of Statistics Teachers. 'Interpretation Anxiety' refers to the feelings of anxiety experienced when interpreting statistical data. The 'Test and Class Anxiety' subscale indicates the anxiety involved during a statistics course or when taking a statistics test. 'Fear of Asking for Help' is defined as the anxiety experienced when seeking help, either from the professor or a fellow student, to comprehend the material covered in class, or any kind of statistical data, or an outcome. 'Worth of Statistics' reflects students' perceptions of the relevance and utility of statistics in their studies, their personal lives, and their future careers. 'Computation Self-Concept' refers to a student's perceived self-efficacy of his or her ability to understand and calculate statistics. Finally, `Fear of Statistics Teachers' relates to the student's perception of the statistics instructor.

The 51-item STARS includes two parts. The first part consists of 23 items aiming to measure statistics anxiety related to situations where students deal with statistics. This part includes the following factors: (a) Interpretation Anxiety, (b) Test and Class Anxiety, (c) Fear of Asking for Help. The assessment was based on a 5-point Likert-type scale ranging from 1 (no anxiety) to 5 (a great deal of anxiety). The second part consists of 28 items dealing with or related to statistics and statistics teachers. This part includes the following factors: (d) Worth of Statistics, (e) Computation Self-Concept, and (f) Fear of Statistics Teachers. The participants were required to rate how much they agree with each of a list of statements on a 5-point Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree). STARS is intercultural and has been used successfully internationally. In addition to English, it has been translated and used in German (Papousek et al., 2012), Chinese (Liu et al., 2011), and Arabic (Nasser, 2004).

Several studies revealed and supported the original six-factor structure of the STARS with the use of student samples in certain countries: the UK (Hanna, Shevlin & Dempster, 2008), the USA (DeVaney, 2016), Austria (Papousek et al., 2012), China (Liu et al., 2011), and South Africa (Mji & Onwuegbuzie, 2004). The six factors showed satisfactory internal consistency in these studies: Cronbach's Alpha coefficient ranged from .72 to .95. Given that the high internal consistency of the overall scale (Baloglu, 2002; Chew & Dillon, 2014; Mji & Onwuegbuzie, 2004; Watson et al., 2003), and the high intercorrelations between the initial STARS subfactors (Baloglu, 2002, 2003; Chew et al., 2018; Hanna et al., 2008; Mij & Onwuegbuzie, 2004; Papousek et al., 2012; Watson et al., 2003), may indicate unidimensionality of the STARS, six-factor models with one superordinate factor were also tested (Chew, Dillon & Swinbourne, 2018; Hanna et al., 2008; Papousek et al., 2012). Also, a six-factor model with two correlated superordinate factors (statistics anxiety and attitudes toward statistics) was limited investigated (Chew et al., 2018; DeVaney, 2016; Papousek et al., 2012). We considered that the specific factorial structure is not testable, because the second superordinate factor "attitudes toward statistics" indicates not only attitudes but also statistics anxiety, as it includes the factor "fear of statistics teachers".

The objectives of the Study

Considering that previous studies have mainly explored the six first order factor model and the six-factor model with one superordinate factor (Chew et al., 2018; Hanna et al., 2008), the main aims of this study were: 1). To investigate the factorial structure and the psychometric properties of the Greek version of STARS. 2). To compare the two aforementioned models in terms of goodness of fit to our data, derived from Greek social sciences students.

Methodology

The Sample

This web survey was conducted in three academic periods, during the first month of the winter semester of 2017, 2018, and 2019. All students enrolled in the introductory statistics course were asked to participate voluntarily and they had to consent for the use of their data according to the new General Data Protection Regulation (GDPR). Moreover, the students were informed that the questionnaire is anonymous, and the data collected will be used solely for research purposes. The sample consisted of 890 students of the third year of study from two departments educational science and childhood in the education of two Greek Universities, the University of Patras (33.1%), and the National and Kapodistrian University of Athens (66.9%). The huge majority of participants were women (97.9%) and this fits with gender's distribution in the total Greek population of students in the departments of early childhood education where approximately 96% of the students are female.

The Research Instruments

Data were collected utilizing a questionnaire, which consisted of two sections of 55 closed-ended questions. Section A included questions regarding students' general characteristics (gender, department of studies) and two items about perceived competence at mathematics (based on a 7-point Likert type scale, 1 = Not good at all .through to 7 = Excellent): a) how good were you in high school mathematics and b) how good are you in mathematics (Lavidas et al, 2020). We used this scale as a validity criterion of STARS. Since we have mentioned that students' perceived competence at mathematics is linked with their statics anxiety (Macher et al., 2011; Williams, 2014). The second section consisted of 51 items of the statistics anxiety rating scale (STARS) (Cruise, et al., 1985). The first 23 "anxiety" items were measured using a five-point scale ranging from 1. no anxiety to 5. very strong anxiety. The other 28 "attitudes" items were measured using a Likert rating scale from 1. Strongly disagree to 5. Strongly agree. The specific direction of responses indicates that the higher scores represent higher anxiety and more negative attitudes toward statistics.

For the adaption of the 51 statements of STARS, we followed a forward and backward translation procedure. Two statisticians with great teaching experience and fluent in both English and Greek translated the items of the STARS. The first researcher translated the items from English to Greek, and the second researcher translated vice versa. The two researchers worked independently and the two English versions, final and authentic were compared. Modifications were made to the Greek versions because of the issues raised from the back-translated items and the fact that the instrument is designed and tested on different groups in different countries.

Finally, to investigate the response bias to the above 51 questions, the Greek version of the social desirability scale (Lavidas & Gialamas, 2019) was administrated to a sample of 35 students, along with the standard questionnaire. No significant correlations support the absence of bias (Lavidas & Gialamas, 2019).

Data Analysis Strategy

Throughout all stages of the factorial analysis, the R environment (R Core Team, 2018) was employed. The final factorial structure was obtained after a series of factor analyses that employed the "lavaan" package (Rosseel, 2012) and the package "semTools" (Jorgensen et al., 2018). Fit indices used to test the factorial structure were the ratio of chi-square to degrees of freedom (χ^2/df), Comparative Fit Index (CFI), Tucker Lewis Index (TLI), and Root Mean Square Error of Approximation (RMSEA). Carmines and McIver (1981) suggested that ratios (χ^2/df) in the range of 2 to 3 are indicative of an acceptable fit. Moreover, values of CFI and TLI close to 0.95 and RMSEA close to 0.06 (Byrne, 2010; Hu and Bentler, 1999) imply an acceptable fit. As an estimator in Exploratory and Confirmatory Factor Analysis, we used a robust WLSMV estimator that does not assume normally distributed variables and can be used for ordered data (Muthén, 1993). This choice was since there were asymmetries in the distributions of the STARS items. Mardia's (1970) estimate of multivariate skewness and kurtosis with the "psych" package (Revelle, 2018), was found very large and statistically significant ($p<.001$).

The data file was divided into two random subsets, "training" sample (N1=442, University of Patras: 35.5% and the Kapodistrian University of Athens: 64.5%, Female: 98.19%) and "validation" sample (N2=448, University of Patras: 30.8% and the Kapodistrian University of Athens: 69.2%, Female: 97.54%) respectively. To validate the six factors (dimensions) of the STARS cross-validation was used in two stages. In the first stage, the factorial structure of STARS was explored with the "training" sample. In the second stage, the derived structure with the remainder independent "validation" sample was confirmed. In both samples factor analysis, the loss of fit was studied, when the second-order factor model fitted. The first-order six-factors model indicates the existence of six correlated factors (subscales of STARS). A second-order factor model suggests that the correlations among the six first-order factors of STARS are explained by one superordinate factor. Finally, the construct validity and reliability for the "training" and "validation" sample were established.

Results

The results of the exploratory factor analysis of the six-factor measurement model with all 51 items (see Table 1) showed an acceptable fit of the model with the data. However, two items (item No. 9: Reading an advertisement for a car which includes figures on miles per gallon, depreciation, etc., and item No. 24: I am a subjective person, so the objectivity of statistics is inappropriate for me) from this factorial structure presented very low loadings ($\lambda<0.4$) and were excluded from the analysis. This decision was based on the fact that the exclusion of these items does not affect the STARS content validity, and simultaneously the remaining items will enhance the convergent validity (Hair et al., 2017). Additionally, the model with remaining items without correlated errors, presented an acceptable fit with the data, in all fit indices (see Table 1), and most loadings were above .7 in all six constructs (see Table 4). Similarly, this factorial structure was confirmed for the "validation" sample too (see Table 1). Finally, in both samples, all fit indices revealed not acceptable fit for the second-order factor model with one superordinate factor.

Table 4 in the appendix shows the six-factor factorial structure for both "training" and "validation" samples. Item loadings were significant, and their standardized values ranged from .518 to .948 with a mean = .780.

Table 1
Fit Indices of the STARS' item, six-factor model, and second-order factor of "training" and "validation" samples.

	x2	**df**	**x2/df**	**TLI**	**CFI**	**RMSEA**	**90%CI (RMSEA)**
"Training" Sample (51 items) six factors	2,851.52	1209	2.36	.945	.942	.057	.053-.060
"Training" Sample (49 items) six factors	2,699.37	1112	2.43	.946	.949	.057	.054-.060
"Training" Sample (49 items) second order one factor	4,660.79	1121	4.16	.880	.886	.085	.082-.087
"Validation" Sample (49 items) six factors	3,052.26	1112	2.74	.939	.942	.062	.060-.065
"Validation" Sample (49 items) second order one factor	4,823.23	1121	4.30	.885	.890	.086	.083-.088

Aiming to establish the construct validity of the derived factorial structure, convergent, and discriminant validity were also investigated (Table 2). Average Variance Extracted (AVE) index with a value at least .50 (Raykov, 2001) and Heterotrait-Monotrait (HTMT) ratio did not exceed the .85 (Henseler, Ringle & Sarstedt, 2014), establishing the convergent and discriminant validity, respectively. For the reliability of the derived factorial structure, Cronbach's a and Composite Reliability (CR) were calculated. Indices' values of at least .70 are considered satisfactory (Raykov, 2001). As shown in Table 2 the values of Cronbach's exceeded the cut off value for both the "training" and the "validation" samples. Finally, the reliability coefficient was excellent (Cronbach's alpha=.933) for the perceived competence at the mathematics scale.

Table 2
Reliability and validity indices for "training" and "validation" samples.

Six Factors	Cronbach's Alpha	Composite Reliability (CR)	AVE	HTMT ratios					
				1	2	3	4	5	6
1	.901(.915)	.905(.918)	.491(.531)	1	(.838)	(.704)	(.500)	(.596)	(.433)
2	.927(.930)	.939(.940)	.660(.665)	.808	1	(.737)	(.485)	(.654)	(.450)
3	.867(.899)	.894(.924)	.680(.765)	.693	.719	1	(.397)	(.427)	(.387)
4	.964(.964)	.968(.968)	.669(.670)	.466	.455	.297	1	(.776)	(.726)
5	.885(.887)	.892(.894)	.551(.555)	.575	.574	.406	.785	1	(.659)
6	.872(.874)	.879(.880)	.595(.596)	.371	.464	.368	.722	.594	1

Notes: 1. Interpretation anxiety, 2. Test and class anxiety, 3. Fear of asking for help, 4. worth of statistics, 5. Computational self-concept, and 6. Fear of statistics teachers.
HTMT. Heterotrait-Monotrait Ratio of Correlations. The indices of the "validation" sample are displayed in parentheses.

Table 3 shows, for the total sample, that students stated declared moderate anxiety (the majority of means ranged from 2 to 3) about statistics. Moreover, all subscales are satisfactory intercorrelated (ranged .301 to .707). Finally, all subscales are negatively correlated with perceived competence at mathematics (Cronbach's Alpha=.933), indicating satisfactory criterion validity of STARS. The less perceived competence at mathematics the higher was the anxiety about statistics.

Table 3

Six factors, descriptive statistics and product-moment correlation coefficient (N=890)

	Mean	SD	1	2	3	4	5	6
1. Interpretation anxiety	2.37	.70	1					
2. Test and class anxiety	3.11	.89	.736**	1				
3. Fear of asking for help	2.14	.87	.593**	.621**	1			
4. worth of statistics	2.13	.77	.448**	.441**	.299**	1		
5. Computational self-concept	2.38	.82	.518**	.546**	.344**	.707**	1	
6. Fear of statistics teachers	2.04	.72	.349**	.400**	.301**	.623**	.522**	1
Perceived competence at mathematics	4.16	1.41	-.408**	-.436**	-.248**	-.481**	-.636**	-.338**

Note: The stars factors and Perceived competence at mathematics are based on 5-points (1 to 5) and 7 points (1 to 7) scale respectively. All correlation is significant at the 0.01 level (2-tailed).

Discussion

The purpose of the study was to validate an adapted Greek version of the STARS. The factorial structure of the STARS was investigated through EFA and CFA. The standardized factor loadings were all positive and statistically significant, ranged from 0.52 to 0.95. Moreover, this factorial structure had satisfactory convergent and discriminant validity. Acceptable internal consistency reliabilities were found in each of the six subscales of the Greek version of the STARS, ranged from .87 to .96. This is in agreement with previous research (Chew et al., 2018; Cruise et al., 1985; DeVaney, 2016; Hanna et al., 2008; Liu et al., 2011; Mij & Onwuegbuzie, 2004; Papousek et al., 2012). For example, Chew et al. (2018) reported internal consistency which ranged from .81 to .94.

This study also contributes to the existing body of the literature by adding evidence of the current status of the factorial structure of the STARS. The results supported that a correlated six first-order factor model provided the best fit to the data compared to a six-factor model with one superordinate factor. Hence, this study also indicates that statistics anxiety is a multidimensional construct, yet useful that expresses much further than a general disposition to anxiety. The results are in agreement with other studies (Chew et al., 2018; DeVaney, 2016; Hanna et al., 2008), which also reported that the six first-order factor model was the best explanation of the data. Thus, it seems that specific items and subscales are unable to measure statistical anxiety directly. On the contrary, many items measure other concepts such as the worth of statistics and computation self-concept. If the STARS measures exclusively statistics anxiety, then the model with one superordinate factor, in which all first-order factors load on a single second-order factor, would make a better fit to the data compared to the original six first-order factor model. Hence, also the Greek version of STARS measures anxiety and attitudes toward statistics.

Also, taking into account the heterogeneity of the items, and the finding that the six factors of the instrument do not measure statistics anxiety exclusively, we consider that factors "Interpretation Anxiety", "Test and Class Anxiety", "Fear of Asking for Help", and "Fear of Statistics Teachers" could be used in order to measure statistics anxiety, whereas factors "Worth of Statistics" and "Computation Self-Concept" probably represent attitudes toward statistics. In light of this conclusion, statistics teachers could influence the situational factors which contribute to statistics anxiety. For example, teachers may remind their students of the importance of previous knowledge and skills that will be needed later, such as solving simple mathematical equations, and in any case minimizing mathematical formalities in teaching statistics (Baloglu et al., 2007; Lavidas et al, 2020). Similarly, teachers could influence the factors that are linked to attitudes toward statistics, such as the dispositional environmental factors. For example, teachers must pay attention to students’ learning styles (Onwuegbuzie & Wilson, 2003; Walsh & Ugumba-Agwunobi, 2002), and enhance the feedback which comes from students’ intellectual ability and perceived creativity (Onwuegbuzie & Wilson, 2003).

Limitations of this study include the origin of the sample exclusively from early childhood education students, the sample consists of students in three consecutive academic years and the use of a quantitative inquiry only. Another limitation of this research was the fact that in Early Childhood Education, the huge majority of students are females. We suggest that this gender bias has no important effect on the factorial structure and the validity of this study, as reported in the other studies with similar instruments (Bechrakis et al., 2011). However, there is a significant gender difference in mean levels of statistics anxiety, as reported in other studies using STARS (Zeidner, 1991; Onwuegbuzie, 1995; Rodarte-Luna and Sherry, 2008; Bechrakis et al., 2011). Statistics anxiety can be further explored in Greece, with more diverse samples (e.g., other disciplines). Moreover, this study could be enriched by using a mixed method (e.g., quantitative, and qualitative approaches) to obtain a better and clear understanding of the characteristics of statistics anxiety. For example, conducting face to face interviews with the students presenting high levels of statistics anxiety could be a useful step for gaining further insight into the deeper feelings of the students, and exploring the causes of statistics anxiety.

Finally, future studies may focus on investigating other aspects of statistics anxiety such as the role of statistics teacher and his/her didactic methods in reducing anxiety, and the influence of students’ social status/cultural background on anxiety during a statistics lesson.

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Appendix

Table 4
Six-factors factorial structure for "training" and "validation" samples (49-item version)

	"Training" Sample		**"Validation" Sample**	
Factor	**Mean (sd)**	**Loadings**	**Mean (sd)**	**Loadings**
1. Interpretation anxiety				
2. Interpreting the meaning of a table in a journal article	2.56 (1.01)	.700	2.42 (1.04)	.665
5. Making an objective decision based on empirical data	2.46 (0.93)	.649	2.42 (1.02)	.674
6. Reading a journal article that includes some statistical analyses	2.06 (1.01)	.683	1.99 (0.99)	.734
7. Trying to decide which analysis is appropriate for my research project	2.90 (1.00)	.728	2.94 (0.99)	.729
9. Reading an advertisement for a car which includes figures on miles per gallon, depreciation, etc.	1.79 (0.94)	----	1.72 (0.91)	----
11. Interpreting the meaning of a probability value once I have found it	2.71 (0.98)	.864	2.66 (0.99)	.810
12. Arranging to have a body of data put into the computer	2.24 (1.06)	.701	2.24 (1.03)	.680
14. Determining whether to reject or retain the null hypothesis	2.83 (0.95)	.720	2.86 (1.04)	.828

17. Trying to understand the odds in a lottery	2.03 (0.94)	.590	2.03 (0.97)	.632
18. Watching a student search through a load of computer printouts from his/her research	1.89 (0.97)	.631	2.00 (1.03)	.730
20. Trying to understand the statistical analyses described in the abstract of a journal article	2.06 (0.92)	.709	2.10 (0.98)	.774
2. Test and class anxiety				
1. Studying for an examination in a statistics course	3.15 (1.03)	.815	3.12 (1.07)	.816
4. Doing the coursework for a statistics course	2.83 (1.10)	.795	2.81 (1.18)	.836
8. Doing an examination in a statistics course	3.85 (1.08)	.910	3.83 (1.07)	.893
10. Walking into the room to take a statistics test	3.64 (1.10)	.919	3.63 (1.10)	.925
13. Finding that another student in class got a different answer than I did to a statistical problem	2.97 (1.09)	.675	3.01 (1.15)	.693
15. Waking up in the morning on the day of a statistics test	3.41 (1.19)	.869	3.40 (1.20)	.823
21. Enrolling in a statistics course	2.19 (1.11)	.790	2.25 (1.22)	.829
22. Going over a final examination in statistics after it has been marked	2.79 (1.21)	.695	2.96 (1.21)	.680
3. Fear of asking for help				
3. Going to ask my statistics teacher for individual help with	2.51 (1.11)	.831	2.48 (1.16)	.877

material I am having difficulty understanding				
16. Asking one of your lecturers for help in understanding a printout	2.35 (1.09)	.888	2.34 (1.15)	.919
19. Asking someone in the computer lab for help in understanding a printout	1.97 (0.96)	.837	2.03 (1.06)	.885
23. Asking a fellow student for help in understanding a printout	1.74 (0.86)	.736	1.73 (0.97)	.789
4. Worth of statistics				
24. I am a subjective person, so the objectivity of statistics is inappropriate for me	2.07 (0.98)	----	2.03 (0.92)	----
26. I wonder why I have to do all these things in statistics when in actual life I will never use them	2.20 (1.02)	.853	2.16 (1.07)	.819
27. Statistics is worthless to me since it is empirical and my area of specialization is abstract	2.02 (0.94)	.832	1.96 (0.94)	.832
28. Statistics takes more time than it is worth	2.11 (0.90)	.775	2.10 (0.93)	.765
29. I feel statistics is a waste	1.78 (0.85)	.815	1.71 (0.83)	.803
33. I lived this long without knowing statistics, why should I learn it now?	1.97 (1.00)	.878	1.99 (1.02)	.864
35. I do not want to learn to like statistics	1.83 (0.96)	.796	1.78 (0.95)	.808
36. Statistics is for people who have a natural leaning toward maths	2.37 (1.14)	.662	2.49 (1.27)	.764

37. Statistics is a pain I could do without	2.27 (1.06)	.873	2.23 (1.09)	.857
40. I wish the statistics requirement would be removed from my academic program	2.73 (1.19)	.836	2.72 (1.26)	.848
41. I do not understand why someone in my field needs statistics	2.11 (0.96)	.858	2.10 (0.96)	.861
42. I do not see why I have to fill my head with statistics. It will have no use in my career	2.02 (0.90)	.889	1.97 (0.90)	.882
45. I cannot tell you why, but I just do not like statistics	2.47 (1.15)	.847	2.51 (1.15)	.840
47. Statistical figures are not fit for human consumption	1.98 (0.83)	.692	1.99 (0.82)	.723
49. Affective skills are so important in my (future) profession that I do not want to clutter my thinking with something as cognitive as statistics	2.14 (0.95)	.770	2.12 (0.90)	.739
50. I am never going to use statistics so why should I have to take it?	2.03 (0.91)	.863	2.03 (0.92)	.857
5. Computational self-concept				
25. I have not done maths for a long time. I know I will have problems getting through statistics	2.92 (1.29)	.765	2.87 (1.28)	.766
31. I cannot even understand secondary	2.07 (1.12)	.745	2.11 (1.15)	.773

school maths; how can I possibly do statistics?				
34. Since I have never enjoyed maths I do not see how I can enjoy statistics	2.21 (1.19)	.948	2.26 (1.23)	.912
38. I do not have enough brains to get through statistics	1.74 (0.88)	.661	1.77 (0.93)	.672
39. I could enjoy statistics if it were not so mathematical	2.56 (1.20)	.852	2.59 (1.17)	.848
48. Statistics is not really bad. It is just too mathematical	3.09 (1.08)	.518	3.15 (1.03)	.558
51. I am too slow in my thinking to get through statistics	1.97 (1.01)	.626	2.04 (1.07)	.620
6. Fear of statistics teachers				
30. Statistics teachers are so abstract they seem inhuman	1.85 (0.86)	.705	1.87 (0.88)	.675
32. Most statistics teachers are not human	1.87 (0.83)	.769	1.92 (0.92)	.766
43. Statistics teachers speak a different language	2.23 (0.98)	.876	2.26 (1.07)	.917
44. Statisticians are more number oriented than they are people oriented	1.90 (0.86)	.782	1.99 (0.92)	.767
46. Statistics teachers talk so fast you cannot logically follow them	2.26 (1.01)	.715	2.30 (1.03)	.714

Konstantinos Lavidas, Department of Educational Sciences & Early Childhood Education, University of Patras.
ORCID ID: http://orcid.org/0000-0003-2225-1137
Contact Address: lavidas@upatras.gr

Dionysios Manesis, Department of Early Childhood Education, National and Kapodistrian University of Athens.

Vasilios Gialamas, Department of Early Childhood Education, National and Kapodistrian University of Athens.