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RELIABILITY AND VALIDITY TESTING OF A NEW SCALE FOR MESURING ATTITUDES TOWARD LEARNING STATISTICS WITH TECHOLOGY

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Abstract. The aims of this paper are to determine the validity and reliability of SASTSc scale as an instrument to measure students' attitudes that monitors affective components relevant to learning the disciple of statistics with the help of technology and its impact on students' career in a Greek sample. Initially, it was consisted of 28 items concerning 5 conceptual subscales which measure students' attitudes concerning Statistics Cognitive Competence, Technology Cognitive Competence, Learning Statistics with Technology, Value of the disciple and Emotions. In particular, the paper reports the responses of 123 Greek students from the department of Pre-school Education of the Western Macedonia University in Greece. The results of the present study provide the final scale, which is consisted of the all the 28 items of the initial SASTS Scale and for which strong evidence was ascertained.

Keywords: Reliability, Validity, Statistics, Techology, Scale

1. Theoretical framework

Many researchers described innovative ways computers are being used in undergraduate and graduate statistics courses and their impact on the way these courses are being taught (Biehler, 1993; Moore, 1997; Ben-Zvi, 2000; Franklin & Garfield, 2006; Callingham, 2010).
Uses of technology discussed included combinations of software programs with new curricular approaches and Internet resources. ICOTS (International Conference of Statistics Education) and IASE (International Assosiation of Statistics Education) conferences have put emphases to the advantages and benefits of computers in statistics education. Chance et all. (2007) argued that it is hard to imagine teaching statistics today without using some form of technology. In addition Garfield et all. (2000) supported that teachers are encouraged to view the use of technology not just as a way to compute numbers but as a way to explore concepts and ideas and enhance student learning.

2. Research goals

Statistics education community pays attention to the impact that technology may have on the learning statistics. Therefore, it is of great interest to investigate the attitudes of professionals, pupils, students and teachers, towards learning statistics with technology. For this reason, the present study aims to create a reliable and valid tool capable to measure the participants' awareness of lifelong learning in connection with the human resources development issue by taking into consideration vital parameters such as, positive and negative attitudes concerning a student's knowledge and skills as applied to statistics, positive and negative attitudes concerning a student's knowledge and skills as applied to technology, positive and negative attitudes concerning a student's attitudes to learning statistics with technology, positive and negative attitudes to the worth and usefulness of statistics in students' personal and professional life, positive and negative emotions concerning statistics towards the learning statistics with the help of technology. This specific tool is under investigation for its reliability and validity as there are no other relative instruments for this type of measurement.

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3. The instrument

The instrument, which intended to measure students' attitudes towards statistics, is Students Attitudes toward Statistics and Technology Scale (SASTSc). This tool consisted of 28 items referring to five different attitude subscales, as follows: (a) Statistics Cognitive Competence-positive and negative attitudes concerning a student's knowledge and skills as applied to statistics (Co1, Co2, Co3, Co4, Co5, Co6); (b) Technology Cognitive Competence-positive and negative attitudes concerning a student's knowledge and skills as applied to technology –computers (Te1, Te2, Te3, Te4); (c) Attitudes to learning statistics with technology (ST1, ST2, ST3, ST4, ST5, ST6) -positive and negative attitudes concerning a student's attitudes to learning statistics with technology; (d) Value- positive and negative attitudes to the worth and usefulness of statistics in students' personal and professional life (Va1, Va2, Va3, Va4, Va5, Va6); (e) Affect- positive and negative emotions concerning statistics (Af1, Af2, Af3, Af4, Af5, Af6). The 28 items have created the above 5 different attitude subclales, thus those subscales are the results of the explamatory factor analysis.
Each item of the instrument used a 5-point Likert scale that ranged from 1- Strongly Disagree to 5-Strongly Agree. The value of the Cronbach's α coefficient for this instrument in this study's sample was 0.901

4. Sample

The sample consists of 123 Greek students from the department of Pre-school Education of the Western Macedonia University. 123 valid questionnaires were collected in the beginning of the first semester of the academic year 2010-11.

5. Methodology

The aim of this research study is to determine the validity and reliability of the SASTSc Scale which was designed as an instrument to measure students' attitudes towards the impact of lifelong learning on the human resources development and it monitors affective components relevant to the lifelong awareness, the educational and vocational training, the culture of lifelong learning, business strategy, value system and ethics, evaluation policy of the programmes' participation, trainee's orientation towards lifelong learning and his/her emotional identity in a Greek sample. The evaluation of questionnaire reliability- internal consistency is possible by Cronbach's α (Cronbach, 1984), which is considered to be the most important reliability index and is based on the number of the variables/items of the questionnaire, as well as on the correlations between the variables (Nunnally, 1978). The reliability of the instrument means that its results are characterized by repeativenes (Psarou and Zafiropoulos, 2004) and these results are not connected with measurement errors (Zafiropoulos, 2005), was evaluated by Cronbach alpha coefficient. The index alpha (a) is the most important index of internal consistency and is attributed as the mean of correlations of all the variables, and it does not depend on their arrangement (Anastasiadou, 2006).

Then a Principal components analysis with Varimax Rotation produces the dimension of differentiation was used in order to confirm or not the scale construct validity. To define if the sub-scales were suitable for factor analysis, two statistical tests were used. The first is the Bartlet Test of Sphericity, in which it is examined if the subscales of the scale are inter-independent, and the latter is the criterion KMO (Kaiser-Meyer Olkin Measure of Sampling Adequacy, KMO) (Kaiser, 1974), which examines sample sufficiency. The main method of extracting factors is the analysis on main components with right-angled rotation of varimax type (Right-angled Rotation of Maximum Fluctuation), so that the variance between variable loads be maximized, on a specific factor, having as a final result little loads become less and big loads become bigger, and finally, those with in between values are minimized (Hair et al., 2005).

This means that the factors (components) that were extracted are linearly irrelevant (Anastasiadou, 2006). The criterion of eigenvalue or characteristic root (Eigenvalue) ≥1 was used for defining the number of the factors that were kept (Kaiser, 1960, Sharma, 1996, Hair et al., 1995). Model acceptance was based on two criteria: a) each variable, in order to be included in the variable cluster of

a factor, must load to it more than 0.5 and b) less than 0.4 to the rest of the factors) (Schene, et al., 1998). Moreover, each factor must have more than two variables. In addition, it was considered, on the basis of common variable Communalities, that the variables with high Communality (h^2) imply great contribution to the factorial model (Hair et al., 2005). For the statistical data elaboration and check of the questionnaire factorial structure the software S.P.S.S., edition 16 was used.

6. Reliability

The following table of Reliability Statistics (Table 1) inform us about the value of the coefficient a of Cronbach for the research scale is 0.908=90,8%. This gets over the percent of 80%, which is an extra good value for the internal consequence of the conceptual construction of the investigated scale (Anastasiadou, 2010; Nouris, 2006). If we continue with the release of units, in other words with the standardized value of the variables, then the coefficient Cronbach a will slightly increase the value of α=0,909. This means that whether we increase the number of the items, then Cronbach a will take the value of 0,909.

Table 1: Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	No of Items
,908	,909	28

The table Scale Statistics (Table 2) gives the scores that are related to the scale's entirety, which presents a mean of the class of 79,10 and a standard deviation of the class of 15,123 units.

Table 2: Scale Statistics

Mean	Variance	Std. Deviation	N of Items
79,10	228,690	15,123	28

The table Item-Total Statistics (Table 3) gives the following important information in particular.

Table 3: Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
co1	76,77	209,757	,699	,716	,902
co2	76,65	208,653	,753	,810	,901
co3	76,55	210,339	,674	,789	,902
co4	76,42	205,979	,723	,756	,901
co5	77,02	214,488	,474	,625	,905
co6	76,85	208,998	,658	,594	,902
te1	75,86	221,368	,225	,714	,909
te2	75,97	216,743	,357	,696	,907
te3	76,74	222,707	,183	,610	,910
te4	76,74	222,730	,162	,514	,911
ST1	75,57	215,981	,451	,567	,906
ST2	75,65	215,453	,438	,615	,906
ST3	75,99	211,322	,582	,691	,903
ST4	75,77	222,979	,180	,428	,910
ST5	75,52	223,697	,127	,470	,911
ST6	75,80	214,338	,442	,479	,906

Va1	75,73	210,379	,615	,697	,903
Va2	76,15	213,265	,574	,597	,904
va3	75,82	212,480	,455	,586	,906
va4	75,64	214,767	,451	,601	,906
va5	76,09	214,392	,425	,565	,906
va6	75,66	216,672	,373	,573	,907
af1	77,03	206,610	,726	,821	,901
af2	76,82	204,258	,713	,844	,900
af3	76,52	203,875	,762	,843	,900
af4	76,79	209,745	,544	,547	,904
af5	76,89	206,943	,629	,606	,902
af6	76,68	215,464	,331	,564	,908

Especially, in the second column of the above table the particular scale of measurement SASTSc gives mean value 76,77, 76,65, 76,55, 76,42, 77,02, 76,85, 75,86, 75,97, 76,74, 76,74, 75,57, 75,65, 75,99, 75,77, 75,52, 75,80, 75,73, 76,15, 75,82, 75,64, 76,09, 75,66, 77,03, 76,82, 76,52, 76,79, 76,89, 76,68 87 units, which means that it presents a decrease of 4,12, 4,35, 2,94, 3,37, 4,21, 3,95, 4,18, 3,93, 2,45, 1,79, 2,07, 3, 3,72, 2,91, 2,91, units, in case the specific items co1, co2, co3 co4 co5 co6, te1, te2, te3, te4, ST1, ST2, ST3, ST4, ST5 ST6 Va1, Va2 va3va4, va5, va6, af1, af2, af3, af4, af5, af6 are omitted from (taken off) the scale. In the fourth column the number 0,699, 0,753, 0,674, 0,723, 0,474, 0,658, 0,225, 0,357, 0,183, 0,162, 0,451, 0,438, 0,582, 0,180, 0,127, 0,442, 0,615, 0,574, 0,455, 0,451, 0,425, 0,373, 0,726, 0,713, 0,762, 0,544, 0,629, 0,331 means that the specific items co1, co2, co3 co4 co5 co6, te1, te2, te3, te4, ST1, ST2, ST3, ST4, ST5 ST6 Va1, Va2 va3va4, va5, va6, af1, af2, af3, af4, af5, af6 appear the Pearson coefficient of correlation of the class 69,9%, 75,3%, 67,4%, 72,3%, 47,4%, 65,8%, 22,5%, 35,7%, 18,3%, 16,2%, 45,1%, 43,8%, 58,2%, 18%, 12,7%, 44,2%, 61,5%, 57,4%, 45,5%, 45,1%, 42,5%, 37,3%, 72,6%, 71,3%, 76,2%, 54,4%, 62,9%, 33,1% with the sum of the rest variables that remain in the scale when these items co1, co2, co3 co4 co5 co6, te1, te2, te3, te4, ST1, ST2, ST3, ST4, ST5 ST6 Va1, Va2 va3va4, va5, va6, af1, af2, af3, af4, af5, vanish each one separately. All the items appear from good up to high correlation coefficients and they will not omit from the scale.

7. Sample suffiency test and sphericity test

The following table 4 (Table 4) gives information about two hypotheses of factor analysis. From the following table, we find out that sample sufficiency index KMO by Kaiser-Meyer-Olkin, which compares the sizes of the observed correlation coefficients to the sizes of the partial correlation coefficients for the sum of analysis variables is 77.2%, and it is reliable because it overcomes 70% by far. In addition, supposition test of sphericity by the Bartlett test (Ho: All correlation coefficients are not quite far from zero) is rejected on a level of statistical significance $p<0.0005$ for Approx. Chi-Square=2908.333. Consequently, the coefficients are not all zero, so that the second acceptance of factor analysis is satisfied. As a result, both acceptances for the conduct of factor analysis are satisfied and we can proceed to it.

Table 4: KMO and Bartlett's Test

Kaiser-Meyet-Olkin measure of sampling adequacy		,772
Bartlett's test of sphericity	Approx. Chi-square	2908,333
	df	378
	Sig.	,000

8. The Scree plot graph

The scree test (Figure 1) produces the following graph, which proceeds to a graphic representation of eigenvalues and guides us to the determination of the number of the essential factorial axes.

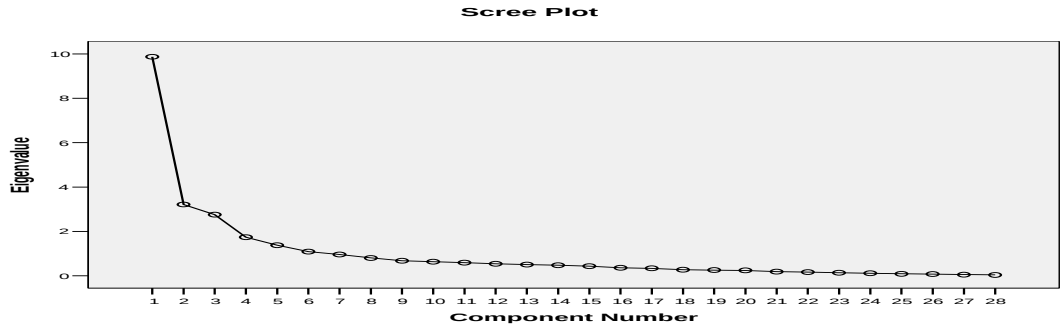

Figure 1: Scree Plot

The above graph (Figure 1) presents a distinguished break up to the eighth factor, whereas after the eighth factor an almost linear part of the eigenvalue curve follows. Thus, we can take under consideration the eigenvalues, which are over 1 for all the five factors (9.870, 3.213, 2.757, 1.741, and 1.380 for the 1st, 2nd, 3rd, 4th and 5th respectively) (Table 5), and decide whether they interpret data in a satisfactory way.

Table 5: Total Variance Explained

Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	9,870	35,250	35,250	9,870	35,250	35,250	7,371	26,325	26,325
2	3,213	11,475	46,725	3,213	11,475	46,725	4,456	15,916	42,241
3	2,757	9,846	56,571	2,757	9,846	56,571	3,001	10,717	52,958
4	1,741	6,217	62,789	1,741	6,217	62,789	2,305	8,233	61,191
5	1,380	4,928	67,717	1,380	4,928	67,717	1,827	6,526	67,717
6	1,089	3,888	71,605						
7	,961	3,431	75,036						
8	,805	2,873	77,910						
9	,676	2,415	80,324						
10	,634	2,263	82,587						
11	,595	2,126	84,712						
12	,540	1,929	86,641						
13	,505	1,804	88,445						
14	,474	1,694	90,140						
15	,436	1,556	91,696						
16	,360	1,286	92,982						
17	,336	1,200	94,182						
18	,272	,971	95,152						
19	,257	,918	96,070						
20	,242	,864	96,934						
21	,185	,661	97,595						
22	,164	,585	98,180						
23	,138	,493	98,673						
24	,113	,402	99,075						
25	,091	,324	99,399						
26	,076	,272	99,671						
27	,052	,186	99,857						
28	,040	,143	100,000						

Extraction Method: Principal Component Analysis.

9. Results

The 123 valid questionnaires were collected with the aim of carrying on a pilot study. It concerns the validity and reliability of the questionnaire which was designed for the working out of a doctoral writing work. We chose to base our estimate on the Principal component analysis with the variance-covariance matrix, because the 28 variables were obtained on a 5-point scale of Likert. The adequacy indicator of the sample KMO=0.772>0.70 indicated that the sample data are suitable for the undergoing of factor analysis. The control of sphericity (Bartlett's sign<0.001) proved that the principal component analysis has a sense. Through this analysis, data grouping was based on the inter-correlation with the aim of imprinting those factors which describe completely and with clarity the participants' attitudes towards the research subject.

According to the analysis (Table 7), arise 5 uncorrelated factors, which explain the 67.717% percentage of the whole inertia of data and are described separately afterwards. The coefficient of internal consistency (reliability) Crobach's a is statistically significant and equals to 90.8% for the total number of questions. That is why the scale of 28 questions was considered as reliable in terms of internal consistency of the conceptual construction that was composed for the attitudes toward learning statistics with technology.

The reliability coefficient (Crobach's a) is statistically significant and equals to 90,1%, 82%, 73,5%, 85,6% and 87,9% for the 1st, 2nd,3rd, 4th and 5th factorial axis correspondingly. Eventually, from the values of the common communality (Table 6) we ascertain for each question that the majority of them have a value higher than 0.50 which represents satisfactory quality of the measurements from the model of 8 factors or components.

Table 6: Communality Table

Communalities

	Initial	Extraction
co1	1,000	,823
co2	1,000	,716
co3	1,000	,699
co4	1,000	,637
co5	1,000	,719
co6	1,000	,743
te1	1,000	,696
te2	1,000	,752
te3	1,000	,717
te4	1,000	,565
ST1	1,000	,630
ST2	1,000	,679
ST3	1,000	,649
ST4	1,000	,523
ST5	1,000	,644
ST6	1,000	,625
Va1	1,000	,778
Va2	1,000	,629
va3	1,000	,664
va4	1,000	,646
va5	1,000	,595
va6	1,000	,682
af1	1,000	,820
af2	1,000	,800
af3	1,000	,810
af4	1,000	,586
af5	1,000	,549
af6	1,000	,586

Extraction Method: Principal Component Analysis.

Table 2 presents the components and the factor loadings produced after Principal Components Analysis. More specifically, based on student attitudes as presented by the factor analysis, questions Co1, Co2, Co3, Co4, Co5 and Co6 particularly with high loadings (0.877, 0.802, 0.800, 0.799, 0.796, 0.749) load mainly on the first axis-factor F1, with eigenvalue 9.870, which explains, following Varimax rotation, 26.325% of the total dispersion. Factor F1 represents students' degree of confidence in relation to understanding statistical reasoning and inference and handling statistics and more specific statistical problems. Finally, last on the significance scale for this factor lays the marks in statistics. This factor highlights the Statistics Cognitive Competence and Confidence domain as the principal component of the source of students' attitudes toward statistics. It is important to mention that all the above items Co1, Co2, Co3, Co4, Co5 and Co6, without exception appear with high loadings on the factor axis-factor, have the Pearson correlation coefficient from good to high and this result to problem non existence in reliability. Reliability of the first factor is a=0.901, which is particularly satisfactory.

Table 7: Principal Componet Analysis

		Factors				
Questions	F1	F2	F3	F4	F5	Communality
Co1: I am confident with statistics	0.877					0.823
Co2: I can understand statistical reasoning easily	0.802					0.716
Co3: I can understand statistical inference easily	0.800					0.699
Co4: I can learn statistics easily	0.799					0.637
Co5: I can solve difficult statistical test-hypothesis problems	0.796					0.719
Co6: I take high marks in statistics	0.749					0.743
Te1: I am very good at computers		0.805				0.696
Te2: I don't have problems at using software		0.766				0.752
Te3: I can easily run SPSS		0.743				0.717
Te4: I can fix many hardware problems in computers		0.741				0.565
ST1: Technology makes the learning of statistics easier			0.838			0.630
ST2: Technology makes the learning of statistics more interesting			0.825			0.679
ST3: Technology helps me to understand statistics			0.739			0.649
ST4: I prefer to use technology to evaluate statistical problems			0.681			0.523
ST5: I like to use computers to make statistical graphs			0.638			0.644
ST6: SPSS software helps to discover many different statistical applications			0.573			0.625
Va1: Statistics is valuable				0.735		0.778
Va2: Statistics makes me overqualified				0.726		0.629
Va3: Statistics is a part of our daily life				0.686		0.664
Va4: Statistics helps me to understand economy				0.668		0.646
Va5: Statistics helps me to understand politics				0.587		0.595
Va6: Statistics helps me to understand reports on the newspapers				0.572		0.682
Af1: Learning statistics is enjoyable					0.721	0.820
Af2: I like learning statistics					0.713	0.800
Af3: Statistics is interesting					0.661	0.810
Af4: Statistics is not a frustrating disciple					0.648	0.586
Af5: I get a lot of satisfaction solving statistical problems					0.640	0.549
Af6: I am not afraid of statistics					-0.611	0.586
Eigenvalue	9.870	3.213	2.757	1.741	1.380	
Variance Explained (%)	26.325	15.916	10.717	8.233	6.526	
Cronbach's a (%)	90.1	82	73.5	85.6	87.9	
Total Variance Explained (%)	67.717					
Total Reliability Cronbach's α (%)	90.8					
Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.772 Bartlett's Test of Sphericity: x^2= 2908.333, df=378, p=0.000						

Questions Te1, Te2, Te3, and Te4 particularly with high loadings (0.805, 0.766, 0.743, 0.741) on the second factor (F2), with eigenvalue 3.213, which explains 15.916% of the total dispersion. The second factor consists of the statements of students who may think that they are very good at computers and they don't have problems at using software, moreover not only they can easily run SPSS but they can fix many hardware problems in computers. All the items Te1, Te2, Te3, and Te4, without exception appear to have high loadings on the second axis-factor, have the Pearson correlation coefficient from good to high and this result to problem non existence in reliability. The reliability of the second factor is a=0.820, which is satisfactory.

Questions ST1, ST2, ST3, ST4, ST5 and ST6 particularly with high loadings (0.838, 0.825, 0.739, 0.681, 0.638, 0.573) on the third factor (F3) with eigenvalue 2.757, which explains 10.717% of the total dispersion. The third factor (F3) consists of the statements of students who may think that technology makes the learning of statistics easier and more interesting, because it helps individuals to understand statistics, who prefer to use technology to evaluate statistical problems and they like to use computers to make statistical graphs and who think that SPSS software helps to discover many different statistical applications. All the items ST1, ST2, ST3, ST4, ST5 and ST6, without exception appear to have either high or low loadings on the third axis-factor, have the Pearson correlation coefficient from good to high and this results to problem non existence in reliability. The reliability of the third factor is a=0.735, which is satisfactory.

Questions V1, V2, V3, V4, V5, V5 and V6, particularly with high loadings (0.735, 0.726, 0.686, 0.668, 0.587, 0.572) are on the fourth factor (F4) with eigenvalue 1.741, which explains 8.233% of the total dispersion. The fourth factor (F4) highlights value of statistics in every day and professional life time demands stress from students.

It is important to stress that the items V1, V2, V3, V4, V5, V5 and appear to have high loading on the fourth factor-axis as well as high correlation coefficient Pearson with the sum of the rest variables that remain in the scale and this results to problem non existence in reliability, and ascertains their remains in the scale. The reliability of the third factor is a=0.856, which is satisfactory.

The fifth and final factor (F5) with eigenvalue 1.380, with quite high loadings (0.721, 0.713, 0.661, 0.648, 0.640, -0.611) which explains 6.526% of the total data inactivity, is constructed and interpreted by questions Af1, Af2, Af3, Af4, Af5 and Af6. The fifth factor consists of variables that concern the positive and negative emotions concerning statistics, named Affect. It is important to give emphasis that the items Af1, Af2, Af3, Af4, Af5 and Af6 appear high loading on the fifth factor-axis as well as high correlation coefficient Pearson with the sum of the rest variables that remain in the scale, and this ascertains their remains in the scale. The reliability of the fourth factor is a=0.879, which is satisfactory.

Finally, the principal factor analysis totally arise seven factor-composite variables, which are named: Statistics Cognitive Competence, Technology Cognitive Competence, Attitudes to learning statistics with technology, Value and Affect. Therefore, a model of five factors is created. Furthermore, it is essential to investigate whether there is a problem in the adaptability of this model.

10. Test of good adaptability

The control of good adaptability as well as the sphericity control prerequisite multidimensional normality. The test of good fit of the five factor model was based on the method of Generalized Weighted Least Squares. By this test the null hypothesis Ho assumes that there is no problem with the good fit of the model to the examined data.

From the table 8 (Table 8) further down we ascertain that the observatory level of statistical significance sign.=0.054>0.05 is over of the cutoff point 5% and therefore we accept the null hypothesis Ho, or in other words, we accept that the estimated five factor model has good fit.

Table 8: Goodness-of-fit Test

Chi-Square	df	Sig.
525,551	248	,054

11. Conclusions

Therefore, a model of five factors has created after the examination of the validity and reliability of the initial Students Attitudes toward Statistics and Technology Scale (SASTSc). The SASTSc Scale constitutes of a 28 item questionnaire and is an instrument useful for measuringstudents' attitudes towards learning statistics with technology and its impact on individual personal and professional life. Principal component analysis made evident seven subscales, named as: Statistics Cognitive Competence, Technology Cognitive Competence, and Attitudes to learning statistics with technology, Value and Affect.

It is worth mentioning that Students Attitudes toward Statistics and Technology Scale (SASTSc) was developed based on student input and was designed as either a pretest or a posttest measure; it appeared to hold considerable promise as a research instrument for identifying the structure of attitudes toward learning statistics with technology.Although this study has provided new insights into the dimensions of Statistics Education as these are outlined in a technology learning world according to new challenges and demands, future research will be needed to more fully understand these dimensions to cotemporary education demands for achieving high echivements. A qualitative research can complement and enrich this quantitative research study and the same research may take place at the end of the studies of our sample graduate students as the comparison of two seems to have huge interest and create new discussions and implications.

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