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Turkish Adaptation of Utley Geometry Attitude Scale: A Validity and Reliability Study

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Abstract

Problem Statement: Among attitude measures, attitude scales are the most common, objective, and effective in gathering attitude data and there is a plenty of scales that measure various factors of attitude towards mathematics. However, there is a need for attitude scales that are content specific such as geometry, algebra, probability and statistics. One reason for this is that students' attitudes towards mathematics in general and their attitudes towards specific mathematical topics might differ considerably from each other. Besides, to hear a student say they like mathematics but dislike geometry or algebra is not uncommon. Thus, it is thought that it would be significant to have a scale that particularly measures learners' attitudes towards geometry.

Purpose of the Study: Although, a number of studies have developed scales with the goal of measuring geometry attitudes of middle and secondary school students, there is no such instrument in the accessible literature in Turkey that serve the same purpose for undergraduate students. Therefore, the authors wanted to go further in this direction and attempted to fill this gap by adapting Utley Geometry Attitude Scale to Turkish.

Methods: The participants of the study consisted of 863 undergraduate students (56 % female; 44 % male) from a public university in the inner part of Turkey. After the list wise deletion of the missing cases, the

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remaining sample (N = 750) was randomly divided into two subsamples to perform factor analysis. Data from the first subsample (n=371) were analyzed by exploratory factor analysis (EFA) to determine the factorial structure of the adapted scale. Later, the data from the second subsample (n=379) were analyzed by confirmatory factor analysis (CFA) to confirm the model obtained from EFA. In addition, item analysis was performed to ensure that there were no problematic items in the adapted scale. Finally, reliability analysis was performed by calculating Cronbach's alpha coefficients both for the adapted scale and its factors.

Findings and Results: After EFA, the translated version of UGAS consisted of a four-factor structure with 25 items. Subsequently, CFA corroborated this four-factor structure and the goodness of fit indices were found to be appropriate for the acceptance of the model. The item total correlations were all larger than .30 and the reliability coefficients for the overall instrument and its factors ranged between .81 and .94.

Conclusions and Recommendations: The results showed that the translated version of UGAS might serve as a valuable instrument both for educators and researchers to measure undergraduate students' attitudes towards geometry.

Keywords: Geometry, attitude scale, undergraduate students, validity and reliability

In mathematics education, the interaction between cognitive and emotional aspects is regarded as affect (Hannula, Evans, Philippou & Zan, 2004). The deep interaction between these two aspects plays a crucial role in mathematics learning and therefore motivates researchers to conduct research on affect in mathematics education (Di Martino & Zan, 2011). Two decades ago, McLeod (1992) made the point that affect plays a crucial role in the teaching and learning of mathematics and added that affective issues have to occupy researchers' minds to a greater extent if we want mathematics education research on learning and instruction to improve its influence on students and teachers. Similarly, Reyes (1984) stated that affect is an important factor for students in deciding how much mathematics is needed in the future and how to approach the mathematical content they study.

McLeod (1992) categorized affective domain into three subdomains: beliefs, attitudes, and emotions. Later, De Bellis and Goldin (1999) suggested 'values' as a fourth subdomain. In this study, the focus will be on the construct of attitude. Over the last forty years, there has been substantial interest in investigating learners' attitudes towards mathematics (Lim & Chapman, 2013). Despite research on attitude has the longest history in the field of affect, it has the most ambiguous theoretical framework and there is a lack of clear and agreed upon definitions (Di Martino & Zan, 2011). For instance, McLeod (1992) proposed a simple definition by assuming that attitudes are "affective responses that involve positive and negative feelings of moderate intensity and reasonable stability. Examples of attitudes towards

mathematics would include liking geometry, disliking story problems, being curious about topology, and being bored by algebra" (p.581). Daskalogianni and Simpson (2000) suggested a bi-dimensional definition of attitude by stating that "attitude is the amalgam of the emotional experiences of a topic and the beliefs about the nature of the topic, which leads to a predisposition to respond with similar emotions and similar expectations in similar experiental settings" (p.222). Hart (1989) described a tripartite model of attitude which includes emotions, beliefs, and behavior. Thereby, he included actions and behavior in his theoretical framework. In their Italian Project about attitude, Zan and Di Martino (2007) asked students to "tell their own stories with mathematics through an autobiographical essay" (p.163) and as a consequence they identified the following three core themes:

> "The emotional disposition towards mathematics, concisely expressed with 'I like / dislike mathematics'; the perception of being /not being able to succeed in mathematics, concisely expressed with 'I can do it /I can't do it'; the vision of mathematics, concisely expressed with 'mathematics is…' " (p.163).

Regardless of these different definitions, studies on learners' attitudes towards mathematics and their relationships with other several constructs is of great importance in mathematics education (Zan, Brown, Evans & Hannula, 2006). Although research on attitude is chiefly based on the belief that attitude towards mathematics is related to achievement in mathematics (Zan et al., 2006), the research literature has failed to provide consistent results with respect to the relationship between these two constructs. Indeed, a number of studies have shown that there is a significant relationship between attitude towards mathematics and achievement in mathematics (e.g., Haladyna, Shaughnessy & Shaughnessy, 1983; Samuelsson & Granstrom, 2007; White, 2001; Yücel & Koç, 2011) while some other researchers reported weak or no correlation between attitude towards mathematics and achievement in mathematics (e.g., Akay & Boz, 2011; Brassell, Petry & Brooks, 1980; Quinn & Jadav, 1987). In their meta-analysis, Ma and Kishor (1997) asserted that the results emerging from different studies are often contradictory and there is a little consensus regarding the relationship between attitude and achievement in mathematics. Consequently, they highlighted that attitude measures need considerable refining.

Among attitude measures, attitude scales are the most common, objective, and effective in gathering attitude data (Aiken, 1985) and there is a plenty of scales that measure various factors of attitude towards mathematics (e.g., Lim & Chapman, 2013; Tapia & Marsh, 2004). However, there is a need for attitude scales that are content specific such as geometry, algebra, probability and statistics (Utley, 2007). One reason for this is that students' attitudes towards mathematics in general and their attitudes towards specific mathematical topics might differ considerably from each other (Bulut et al., 2002). Besides, "to hear a student say they like mathematics but dislike geometry or algebra is not uncommon" (Utley (2007, p.89). Among these content domains, geometry is pivotal in that it helps students learn to reason and see the axiomatic structure of mathematics (National Council of Teachers of Mathematics [NCTM], 2000, p.41) and is covered intensively in all grade levels of school

mathematics curriculum. However, although geometry is an important domain, there are few attitudinal scales that are specific to it (e.g., Bulut, Ekici, İşeri & Helvacı, 2002; Duatepe & Ubuz, 2007; Mogari, 2004; Utley, 2007). Thus, it is thought that it would be significant to have a scale that particularly measures learners' attitudes towards geometry.

Bulut et al. (2002) attempted to develop a scale for measuring eighth and tenth grade students' attitudes towards geometry. The exploratory factor analysis results showed that the scale had three factors: 'enjoyment', 'usefulness' and 'anxiety'. However, the Cronbach's alpha reliabilities of the 'usefulness' and 'anxiety' factors were below .70 since the number of items included in these two factors were very few. As suggested by Bulut and her colleagues, Bayram (2004) added several new items to these factors to enhance the internal validity of the scale and its factors. As a consequence, the three factors of the extended scale had alpha reliabilities that are over .80. Similarly, Duatepe and Ubuz (2007) stated that students' attitudes towards and achievement in geometry is low and thus they considered it important to determine attitude towards geometry with an instrument. Attributing to the fact that motivation and self-confidence are the main descriptors of achievement in mathematics (Ercikan, McCreith & Lapointe, 2005), they developed a geometry attitude scale for eight graders that consist of the aforementioned two factors.

Unlike previous researchers, Mogari (2004) focused on ninth grade students to develop and validate a scale to determine the impact of the ethno-mathematical treatment on students' attitudes towards Euclidean geometry. Mogari developed and validated his geometry attitude scale by modifying Aiken's (1979) attitudinal scale. More specifically, the scale was confined to geometry by substituting 'mathematics' with 'geometry' in all the statements of Aiken (1979). The principal component analysis revealed a four-factor scale including 20 items. The factors measured students' enjoyment of geometry, confidence to study geometry, perceived value of geometry, and lastly the obligatory feeling to study geometry. Likewise, Bindak (2004) stated that affective domain is at least as important as cognitive domain, therefore there is a need for valid and reliable instruments that measure secondary school students' attitude towards geometry properly. To fill this void, Bindak developed a 25-item geometry attitude scale that contains the following four factors: 'enjoyment', 'anxiety', 'avoidance', and 'interest'. Bindak further investigated the relationship between students' demographic characteristics (i.e., gender, socioeconomic status, GPA scores for primary education) and their attitudes towards geometry. The results revealed that while students' geometry attitude scores significantly correlated with GPA scores, their geometry attitudes did not significantly differ in terms of gender and socioeconomic status. In a recent study, Utley (2007) developed and established the validity of a geometry attitude scale to measure undergraduate students' attitudes towards geometry. To be more specific, the participants majored in a wide majority of programs including education, agricultural economics, aviation, business management, fire protection, pre-law, pre-med, and zoology. The principle component analysis indicated that Utley Geometry Attitude Scale (UGAS) has three components: 'confidence', 'usefulness', and 'enjoyment'.

Although, a number of studies have developed scales with the goal of measuring geometry attitudes of middle and secondary school students (e.g, Bayram, 2004; Bindak, 2004; Bulut et al., 2002; Duatepe & Ubuz, 2007; Eryiğit, 2010; Mogari, 2004), there is no such instrument in the accessible literature in Turkey that serve the same purpose for undergraduate students. Therefore, we want to go further in this direction and attempt to fill this gap by adapting Utley Geometry Attitude Scale (Utley, 2007) to Turkish. By this way, it is expected that the adapted version of the UGAS would be helpful for researchers seeking to determine Turkish undergraduate students' geometry attitudes. Besides, as mentioned by Zan et al. (2006), affective outcomes such as Turkish undergraduate students' attitudes towards geometry are significant not only per se but also for the identification of the relationship with achievement in geometry.

Method

This study aimed to contribute to the work on factor structure and psychometric properties of the Utley Geometry Attitude Scale (Utley, 2007) by translating it into Turkish and evaluating its validity and reliability through undergraduate students in a Turkish sample. Participants, instrument and the data analysis of the study are as follows.

Sampling

The participants of the study were 863 undergraduate students from a public university in the inner part of Turkey. Convenience sampling method was used in the selection of the public university. Besides, cluster random sampling was used to select the group of students who were enrolled in the following departments: elementary mathematics education, elementary science education, primary education, mathematics, mechanical engineering, civil engineering, and geomatics engineering. The participants were enrolled in education, science and letters and engineering faculties in the spring semester of 2012. Table 1 shows some characteristics of the participants.

Table 1.

Characteristics of the Participants

Faculty	Department	Gender		f (%)
		Male	Female	
Education	Elementary Mathematics Education	65 (7.53)	159 (18.42)	224 (25.95)
	Elementary Science Education	31 (3.59)	55 (6.37)	86 (9.96)
	Primary Education	24 (2.78)	54 (6.26)	78 (9.04)
Science and Letters	Mathematics	75 (8.69)	158 (18.31)	233 (27.00)
Engineering	Mechanical Engineering	104 (12.05)	22 (2.55)	126 (14.60)
	Civil Engineering	62 (7.18)	25 (2.90)	87 (10.08)
	Geomatics Engineering	19 (2.20)	10 (1.16)	29 (3.36)

Total	380 (44.03)	483 (55.97)	863 (100)

Instrument

In this study, undergraduate students' attitudes towards geometry were measured through a translated (into Turkish) version of the Utley Geometry Attitude Scale (UGAS) (Utley, 2007). The UGAS for undergraduate students is a 32-item self-report scale including 17 positively and 15 negatively worded items. Each item is rated on a 5-point Likert type scale ranging from 5 (strongly agree) to 1 (strongly disagree). UGAS included three factors: confidence (12 items, e.g., I am sure that I can learn geometry concepts), usefulness (10 items, e.g., I can see ways of using geometry concepts to solve everyday problems), and enjoyment (10 items, e.g., Solving geometry problems is enjoyable). Possible student scores on the UGAS range from 32 to 160. Higher scores on the UGAS indicate more favorable attitudes towards geometry.

Forward translation and backward translation are the two most popular judgmental designs that are used for adapting tests (Hambleton, 2005). In this study, the back-translation design was used to adapt UGAS into Turkish. That is, the source and target language of the geometry attitude scale was English and Turkish respectively. Firstly, two bilingual mathematics teacher educators with a PhD degree in mathematics education translated the original items into Turkish. Then, the Turkish and English versions of the UGAS were checked for semantic, idiomatic, experiential, and conceptual equivalence. Since both versions aimed to measure undergraduate students' attitudes towards geometry, the translated versions of the concepts, words, and expressions readily made sense for Turkish undergraduate students. Secondly, the items were back-translated into English by another two bilingual mathematics teacher educators with a PhD degree in mathematics education. Then the original and the back-translated versions of the scale were compared and judgments were made about their equivalence. That is, adjustments were made to the Turkish version when some inconsistencies were found in the meaning of the original and back-translated versions of the scale.

Data Analysis

Before the data analysis, the data set was checked for errors. That is, each of the variables was checked for scores that are out of range and in turn the errors in the data file were found and corrected (Pallant, 2007). Next, the data set were examined for missing values and it was decided to deal with missing data by using exclude cases list wise option. After the list wise deletion of the missing cases, the remaining sample (N = 750) was randomly divided into two subsamples. Data from the first subsample (n=371) were analyzed by exploratory factor analysis (EFA). EFA was performed by using SPSS 18. More specifically, principal component analysis (PCA) was performed to identify the number of dimensions in the scale. According to Tabachnick and Fidell (2007), orthogonal rotation produces solutions that are easier to interpret and report. Therefore, the orthogonal rotation with Varimax method was used to interpret the data from the first subsample of this study. Several iterations of

the factor analysis for orthogonal rotation were performed until a clear factor structure emerged. Besides, the following criteria were followed in the deciding which items should be deleted or not: (a) item loadings have to exceed .40 on at least one factor (Thorndike, 1978); (b) for the items with factor loadings exceeding .30 on more than one factor, a minimum gap of .10 between loadings is required (Nunnally, 1978); and (c) at least 3 significant loadings are required for factor identification (Zwick & Velicer, 1986).

Brown (2006) noted that "Confirmatory factor analysis (CFA) is almost always used during the process of scale development to examine the latent structure of a test instrument" (p.1). In this study, CFA was performed to verify factor structure (i.e., number of factors and factor loadings) on 25 items of UGAS drawn from EFA. Meanwhile, CFA was performed through the statistical software package, LISREL 8.8 (Jöreskog & Sörbom, 2007).

Finally, item analysis and reliability analysis were performed in order to guide the identification and elimination of problematic items from the final version of the adapted instrument. Item analysis was conducted through calculating item discrimination indices of each item. In this study, item discrimination indicated how effectively an item discriminates between participants who have high geometry attitudes and those who have low geometry attitudes. Item discrimination indices of each item were obtained through calculating corrected item-total correlations. Values of .30 or higher were considered to be acceptable (Nunnally & Bernstein, 1994). Besides, the *t* test statistics was conducted to test the significance of the difference between the item scores of upper 27% and lower 27% groups of total score. Lastly, reliability of the overall instrument and its factors were examined via computing Cronbach's alpha coefficients.

Results

In this section, exploratory and confirmatory factor analysis results were reported to establish the construct validity of the adapted instrument and alternately item analysis and reliability analysis results were presented.

Exploratory factor analysis

To assess the suitability of our data for factor analysis, we considered the following two issues: sample size and the strength of the relationship among the items (Pallant, 2007). Based on the recommendations of Nunnaly (1978), it was assumed that the sample size was adequate for factor analysis. To address the second issue, the correlation matrix for evidence of coefficients greater than .30 were inspected (Tabachnick & Fidell, 2007) and this revealed the presence of very few coefficients below .30. In addition to this, two statistical measures generated by SPSS were inspected to assess the factorability of the data. That is, Bartlett's test of sphericity (Bartlett, 1954) was highly significant $(\chi^2(496) = 5730.06,\ p < .001)$ and the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (Kaiser, 1974) was .94, exceeding the recommended value of .60. These statistical measures showed that the magnitudes of the correlations among the items were adequate and that the data were factorable.

We used principal component analysis (PCA) to identify the potential factors for the 32-item adapted instrument. More specifically, we used the varimax rotation to minimize the number of variables that have high loadings on each factor (Pallant, 2007). Using Kaiser's criterion we were interested only in components that have an eigenvalue of 1.0 or more. According to this criterion, the initial analysis extracted 6 factors with eigenvalues greater than one. These six factors accounted for 59.97% of the total variance. The eigenvalues of the first six factors were: 12.06, 1.94, 1.66, 1.41, 1.08, and 1.04 respectively. Additionally, we conducted Catell's scree test (Catell, 1966) to identify the number of factors retained. Similar to Kaiser's criterion, the scree plot revealed six factors. Zwick and Velicer (1986) argued that Kaiser's criterion and Catell's scree test tend to overestimate the number of factors and they recommended using parallel analysis in addition to these two techniques. Thus, we preferred to rely on parallel analysis approach in deciding the number of factors to retain. Then, we ran Monte Carlo PCA for Parallel Analysis (Watkins, 2000) and specified the number of variables, subjects and replications in the following order: 32, 371, and 1000. We systematically compared the eigenvalues obtained in SPSS with the corresponding values from the random results generated by the parallel analysis. The results are summarized in Table 2.

Table 2.

Eigenvalues Obtained Through Principal Component Analysis and Parallel Analysis

Component number	Actual eigenvalue from PCA	Criterion value from parallel analysis	Decision
1	12.06	1.59	accept
2	1.94	1.51	accept
3	1.66	1.46	accept
4	1.41	1.40	accept
5	1.08	1.36	reject
6	1.04	1.28	reject

The results revealed that the first four actual eigenvalues from PCA were larger than the corresponding criterion values from the parallel analysis. However, the fifth eigenvalue from PCA was smaller than the corresponding parallel analysis value. Therefore, we decided to retain four factors for further investigation.

Before making a final decision about the number of factors, we looked at the Rotated Component Matrix. This matrix presents the pattern of loadings in a manner that is easier to interpret (Tabachnick & Fidell, 2007). We used the criteria reported in data analysis section of this paper in deciding whether to retain or delete the items from the adapted instrument. To reiterate, the following criteria are used: (a) item loadings have to exceed .40 on at least one factor; (b) for the items with factor loadings exceeding .30 on more than one factor, a minimum gap of .10 between loadings is required; and (c) at least 3 significant loadings are required for factor identification. Based on these criteria, we decided to delete Item 9 since it loaded

negatively on the sixth factor (-.84). In addition, we deleted Item 1, Item 10, and Item 22 since they did not satisfy criterion b.

After deleting the aforementioned four items, the second principle component analysis with varimax rotation was performed. This time, the number of extracted factors reduced to five. Yet, Item 4 had to be removed because it did not satisfy the criterion b. In addition, Item 12 and Item 15 were the only two items that loaded on the fifth factor and the reliability of this factor with those two items loaded was very low (Cronbach's alpha = .39). Therefore, Item 12 and Item 15 were deleted due to their low reliability alone and not satisfying criterion c.

Ultimately, after eliminating the aforementioned seven items (i.e., Item 1, Item 4, Item 9, Item 10, Item 12, Item 15, and Item 22) from the 32-item adapted instrument, the third principal component analysis was performed. PCA revealed the presence of four factors with eigenvalues exceeding one. The eigenvalues of these factors were 10.20, 1.90, 1.48, and 1.27 and they explained 40.83%, 7.62%, 5.92%, and 5.11% of the total variance respectively. The four-factor solution explained a total of 59.49% of the variance. Kaiser's criterion, Catell's scree test and parallel analysis techniques converged on four factors to retain. To aid in the interpretation of these four components, varimax rotation was performed. The rotation solution revealed the presence of simple structure (Thurstone, 1947), with all factors showing a number of strong loadings and all items loading substantially on only one component. Factor loadings and communalities of the final version of the adapted UGAS is presented in

Table 3.

Factor Loadings and Communalities (η^2) of the 25-Item Adapted UGAS for the Principal Component Analysis after Varimax Rotation

Item#	Factor loadings after the rotation				η^2	Item#	Factor loadings after the rotation				η^2
	F1	F2	F3	F4			F1	F2	F3	F4	
21	**.768**	.124	.235		.662	26	.225	.212	**.812**		.765
18	**.717**	.309	.123		.626	24		.184	**.779**	.215	.687
27	**.713**	.270	.127	.103	.607	28	.245	.254	**.748**	.156	.708
5	**.656**	.225		.214	.529	2	.175	.291	**.499**	.241	.423
8	**.653**	.147	.148	.189	.505	17	.140			**.757**	.601
11	**.638**	.190	.123		.467	20	.109	.148	.267	**.701**	.596
13	**.619**	.234		.369	.577	31	.167	.269	.335	**.660**	.648
32	**.570**	.308		.409	.588	29	.343	.283		**.507**	.463
6	**.522**	.266	.145	.225	.415						
23	.232	**.736**	.152	.327	.726						
14	.251	**.691**	.150	.294	.650						
7	.237	**.685**	.185	.103	.570						
30	.212	**.683**	.136	.291	.614						
19	.186	**.660**	.336	-.100	.593						
16	.294	**.656**	.206	.310	.656						
3	.371	**.637**	.169		.575						
25	.392	**.625**	.265		.622						

Note: Numbers in bold represent the highest salient factor loadings on a factor.

The items loaded on the first factor highlighted undergraduate students' confidence in learning geometry. Thus, the first factor was named as 'Confidence' and it consisted of 9 items. The items loaded on the second factor involved students' enjoyment of working geometry problems. Hence, the second factor was labeled as 'Enjoyment' and it included 8 items. The items loaded on the third factor were concerned with students' use of geometry in the future. Therefore, the third factor was named as 'Future Use' and it included 4 items. Finally, the items loaded on the fourth factor were related with students' everyday use of geometry. Therefore, the fourth factor was entitled as 'Everyday Use' and it contained 4 items. The items covered by each factor are presented in Table 4.

Table 4.

Factors and the Related Items of the Adapted Version of the UGAS

Factors		Items
CONFIDENCE	5.	I often have trouble solving geometry problems.*
	6.	When I start solving a geometry problem, I find it hard to stop working on it.
	8.	I am confident I can get good grades in geometry.
	11.	I lack confidence in my ability to solve geometry problems.*
	13.	I feel sure of myself when doing geometry problems.
	18.	For some reason even though I study, geometry seems unusually hard for me.*
	21.	Geometry problems often scare me.*
	27.	Geometry tests usually seem difficult.*
	32.	I have a lot confidence when it comes to studying geometry.
ENJOYMENT	3.	Geometry problems are boring.*
	7.	Time drags during geometry class.*
	14.	Geometry is fun.
	16.	Geometry is an interesting subject to study.
	19.	Geometry is not worthwhile to study.*
	23.	Solving geometry problems is enjoyable.
	25.	Working out geometry problems does not appeal to me.*
	30.	Geometry has many interesting topics to study.
FUTURE USE	2.	I believe that I will need geometry for my future.
	24.	I will need a firm understanding of geometry in my future work.
	26.	I do not expect to use geometry when I get out of school.*
	28.	I will not need geometry in my future.*
EVERY DAY USE	17.	I can see ways of using geometry concepts to solve everyday problems.
	20.	I often see geometry in everyday things.
	29.	I can usually make sense of geometry concepts.
	31.	Geometry is a practical subject to study.

* Negatively worded items

Confirmatory Factor Analysis

In the present study, Confirmatory Factor Analysis (CFA) was performed on the second subsample $(n = 379)$ to confirm the structure model obtained from the EFA analysis. That is, CFA was conducted to verify the four-factor 25-item UGAS derived through EFA. Thereby, it was analyzed whether the factor structure of the original form of the UGAS could be verified using a sample consisting of Turkish undergraduate students. To this end, the maximum likelihood method was utilized to estimate the parameters of the model (Raykov & Marcoulides, 2000) and several Goodness- of-Fit Indices were inspected to determine whether the model indicates a good or poor fit. In essence, fit indices are usually influenced by various aspects of the analytic situation such as sample size, model complexity, estimation method, amount and type of misspecification, normality of data, and type of data and therefore there is not much consensus in relation to recommended fit index cutoffs (Brown, 2006). Bearing in mind that fit indices have some strengths and weaknesses when compared to each other in the evaluation of the fitness between the theoretical model and the actual data, the following indices were interpreted simultaneously: Chi-Square Goodness of Fit (χ^2), Chi-Square / Degrees of Freedom (χ^2 / df), Goodness of Fit Index (GFI), Adjusted Goodness of Fit Index (AGFI), Root Mean Square Error of Approximation (RMSEA), Root Mean Square Residuals (RMR), Standardized Root Mean Square Residuals (SRMR), Comparative Fit Index (CFI), Normed Fit Index (NFI), Non-normed Fit Index (NNFI), Parsimony Normed Fit Index (PNFI), Relative Fit Index (RFI), Incremental Fit Index (IFI), and Parsimony Goodness of Fit Index (PGFI). The values of each index derived in this study are presented in Table 5.

Table 5.

Fit Index Values Obtained in This Study

Fit Index	Obtained value	Fit Index	Obtained value
χ^2	800.73	CFI	.97
χ^2 / df	2.98	NFI	.96
GFI	.86	NNFI	.97
AGFI	.82	RFI	.95
RMSEA	.072	IFI	.97
RMR	.060	PNFI	.86
SRMR	.060	PGFI	.71

χ^2 Goodness-of-Fit statistic is a popular way of evaluating the model fit (Hu & Bentler, 1999) and a good model fit is expected to provide a no significant result at a .05 threshold (Barrett, 2007). However, in this study χ^2 statistic provided a significant result $(\chi^2(sd = 269) = 800.73,\ p = 0.00)$. This is most probably due to the fact that χ^2 statistic is sensitive to sample size and therefore it nearly always rejects the model when large samples are used (Jöreskog & Sörbom, 1993). To diminish the sensitivity, the evaluation of χ^2 / df ratio is suggested (Marsh, Balla & McDonald, 1988). For this ratio, a cutoff value less than 3 corresponds to a perfect model fit (Kline, 2011). Therefore, in the current study, there is a perfect fit between the theoretical model and the actual data. Raykov and Marcoulides (2000) noted that the χ^2 value and its *p* value alone cannot be entirely dependable when evaluating the model fit and they recommend researchers also to examine other fit indices so as to get a better picture of model fit. Among these fit indices, GFI, AGFI, CFI, NFI, NNFI, RFI, and IFI have an acceptable fit value of .90 and a perfect fit value of .95 (Bentler & Bonett, 1980; Hooper, Coughlan & Mullen, 2008; Hu & Bentler, 1999; Schumacker & Lomax, 2004; Tabacknick & Fidel, 2007; Kelloway, 1998). In this study, GFI and AGFI fit index values were below .90. Thus, the GFI and AGFI values indicated a poor fit to the data. On the contrary, CFI, NFI NNFI, RFI, and IFI values indicated a perfect model fit since their values were equal to or above .95. On the other hand, RMSEA, RMR, and SRMR values less than .05 suggest perfect model fit and values less than .08 suggest good model fit (Brown, 2006; Byrne, 1994; Hooper, Coughlan & Mullen, 2008; Hu & Bentler, 1999; Raykov & Marcoulides, 2008). Hence, RMSEA, RMR, and SRMR indices of this study provided a good model fit. Finally, although no threshold level is suggested for PNFI and PGFI index, Kelloway (1998) stated that parsimony fit indices range between 0 and 1, with higher values indicating a more parsimonious fit. Mulaik et al (1989) explained that it is probable to obtain parsimony fit indices in the .50s. Therefore, the PNFI of .86 and the PGFI of .71 obtained in this study indicated good model parsimony. In general, CFA showed that the model reflected the empirical data because all fit indices except for GFI and AGFI were appropriate for the acceptance of the model.

The interpretation of individual parameter estimates is indispensable for any model analysis since they can be meaningless although the model fit criteria suggest acceptable structural model (Schumacker & Lomax, 2004). Thereby, we present the path diagram for the four-factor model in Figure 1 and then examine the statistical significance, the magnitude and the direction of individual parameter estimates for the paths in the model. In the figure, the circles and rectangles represent latent constructs and measured variables respectively. A one-way straight arrow going from the latent variable to its observed variables indicate that a factor loading will be computed.

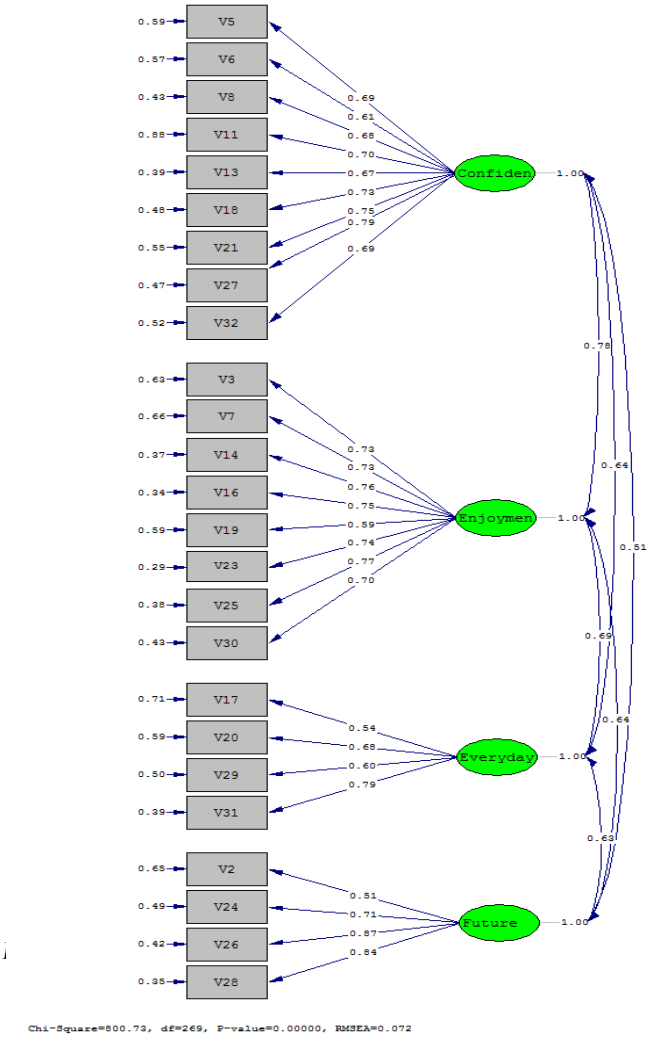

Figure 1. The path diagram for the four-factor model

The t-values estimation showed that all individual parameter estimates for the paths in the model were statistically significant. As a reference, parameter estimates are significant at the .05 level if the *t* value exceeds 1.96 and at the .01 level if the *t* value exceeds 2.56 (Hoyle, 1995). In this study, the *t* values were all between 10.25 and 17.99. Therefore, parameter estimates were all statistically significant at the level of .01. Apart from this, the error variances of observed variables in the path diagram that were produced as a result of standardized solution estimates ranged between .29

and .88 (See Figure 1). This showed that the error variances of the observed variables were not high.

As seen in Figure 1, the standardized path coefficients were all positive and ranged between 0.51 and 0.87. The range of path coefficients for each factor is as follows: .61 - .79 for 'confidence' factor, .59 - .77 for 'enjoyment' factor, .54 - .79 for 'everyday use' factor, and .51 - .87 for 'future use' factor. Thereafter, no model modification indices were evaluated since the data-model fit as it stands was satisfactory.

Item Analysis and Reliability Analysis

After EFA and CFA, item analysis was performed in order to identify and eliminate problematic items from the 25-item adapted UGAS. To do so, item discrimination indices of each item was calculated. In this study, item discrimination indicated how effectively an item discriminates between participants who have high geometry attitudes and those who have low geometry attitudes. Item discrimination indices were checked through corrected item-total correlation values and through *t-test* statistics for the significance of the difference scores between 27% of the lower and upper groups. Corrected item-total correlation values indicate the degree to which each item correlates with the total score (Pallant, 2007). Values of .30 or higher are considered to be acceptable (Nunnally & Bernstein, 1994) and a value less than .30 signals that the item might be measuring something different from the scale as a whole. The no significant *t*-value for an item indicates that the item cannot discriminate between participants who have high geometry attitudes and those with lows geometry attitudes. The corrected item-total correlations (*r*) and the t-values for each item are presented in Table 6.

Table 6.

The Corrected Item-Total Correlations (R) and the t-Values for the Adapted Version of the UGAS

Item#	*r*	Upper Group		Lower Group		*t*	Item#	*r*	Upper Group		Lower Group		*t*
		M	*SD*	*M*	*SD*				*M*	*SD*	*M*	*SD*	
2	.49	4.64	.67	3.22	1.12	10.97*	20	.46	4.12	.85	2.77	1.16	9.44*
3	.64	4.76	.63	2.89	1.24	13.58*	21	.58	4.56	.64	2.82	1.13	13.54*
5	.56	4.27	.85	2.72	1.09	11.35*	23	.71	4.82	.39	3.14	1.15	13.89*
6	.58	4.42	.68	3.04	1.08	10.84*	24	.45	4.29	.84	3.11	1.07	8.75*
7	.61	4.71	.78	2.88	1.25	12.45*	25	.71	4.95	.26	3.01	1.23	15.49*
8	.62	4.51	.63	3.02	1.08	11.96*	26	.54	4.60	.80	3.00	1.10	11.88*
11	.53	4.52	.85	2.80	1.13	12.25*	27	.62	4.51	.83	2.63	1.03	14.33*
13	.63	4.44	.59	3.08	1.09	11.07*	28	.58	4.74	.64	3.04	1.10	13.48*
14	.67	4.87	.34	3.08	1.10	15.76*	29	.58	4.34	.75	3.00	1.04	10.51*
16	.72	4.78	.54	3.08	1.14	13.67*	30	.64	4.68	.47	3.08	1.19	12.60*

Table 6 Continue

Item#	*r*	Upper Group		Lower Group		*t*	Item#	*r*	Upper Group		Lower Group		*t*
		M	*SD*	*M*	*SD*				*M*	*SD*	*M*	*SD*	
17	.37	3.95	1.01	2.79	1.09	7.90*	31	.59	4.46	0.7	2.86	1.06	12.69*
18	.62	4.69	.61	2.99	1.13	13.34*	32	.62	4.47	0.63	2.83	1.19	12.33*
19	.54	4.79	.65	3.46	1.20	9.92*							

* $p < .01$

As it can be seen in Table 6, the corrected item-total correlation values of each item ranged between .37 and .72. This suggested that all items were working well and there was no need to eliminate any item from the scale. Another method that was used to identify how well an item is able to distinguish between participants who have higher and lower attitudes was testing the significance of difference scores of the upper 27% and lower 27% of the whole participants. The *t*-test values given in Table 6 were all found to be significant at the level of .01. This finding also corroborated that each item included in the adapted UGAS was working efficiently.

Ultimately, reliability of the final version of the UGAS was assessed by means of internal consistency measures. The reliability of the overall instrument and its factors was measured by the most commonly used statistics, Cronbach's coefficient of alpha (α) (Pallant, 2007). Preferably, α value of a scale should be above .70 (DeVellis, 2003). Similarly, George and Mallery (2003) reported the following rule of thumb for describing the internal consistency: if α is above .90, then the internal consistency is excellent; if α is between .90 and .80, then the internal consistency is good and if α is between .80 and .70 range, then the internal consistency is acceptable. In the current study, Cronbach's alpha coefficients for the 'confidence', 'enjoyment', 'everyday use' and 'future use' factors and for the overall instrument were found to be .89, .91, .76, .81, and .94 respectively. This revealed that the overall adapted instrument and the 'enjoyment' factor had excellent internal consistencies. In addition, while 'confidence' and 'future use' factors had good internal consistencies, 'everyday use' factor had an acceptable internal consistency.

Discussion and Conclusion

Although there are many scales that measure learners' attitudes towards mathematics, there is a lack of content specific instruments such as geometry attitude scales. Besides, already existing geometry attitude scales are relevant for either middle or secondary school students. Therefore, this study explored the psychometric properties and the construct validity of the Turkish translation of the Utley Geometry Attitude Scale developed by Utley (2007) for undergraduate students. Data were divided into two random subsamples to perform factor analysis. EFA was conducted on the first subsample to determine the factorial structure of the

translated version of the scale. Next, CFA was conducted on the second subsample to test the fit of the model obtained through EFA. Following EFA, the 25-item UGAS with the following four dimensions were obtained: 'confidence', 'enjoyment', 'everyday use' and 'future use'. CFA was performed to test whether this four factor structure indicates a good model fit. In general, the model reflected the empirical data since goodness of fit indices were found to be appropriate for the acceptance of the model $((\chi^2(sd = 269) = 800.73,\ p = 0.00),\ \chi^2 / df = 2.98,\ \text{GFI} = .86,\ \text{AGFI} = .82,\ \text{RMSEA} = .072,\ \text{RMR} = .060,\ \text{SRMR} = .060,\ \text{CFI} = .97,\ \text{NFI} = .96,\ \text{NNFI} = .97,\ \text{RFI} = .95,\ \text{IFI} = .97,\ \text{PNFI} = .86,$ and $\text{PGFI} = .71)$. After CFA, item analysis and reliability analysis were performed to determine item discrimination indices of each item and reliability coefficients of the scale and its factors. The corrected item-total correlations and the t-values showed that all items were discriminating satisfactorily. Ultimately, Cronbach's alpha coefficients were calculated to assess the internal consistency of the 25-item UGAS and its factors. Alpha reliabilities for the overall scale and for the 'confidence', 'enjoyment', 'everyday use' and 'future use' factors were found to be .94, .89, .91, .76, and .81 respectively.

The alpha reliabilities for the translated version of the instrument and its factors have been found to be slightly lower when compared to the alpha values of the original instrument (UGAS). This might have stemmed from the fact that the translated version and its factors included fewer items when compared to UGAS. In other words, the Turkish version had 9-8-4-4 items in its factors while UGAS had 12-10-10 items. Moreover, the usefulness factor of UGAS turned out to be as two factors, (i.e., 'everyday use' and 'future use) in the Turkish version. Both of these factors include four items and have low reliabilities when compared to 'confidence' and 'enjoyment' factors. Especially, 'everyday use' factor has the lowest reliability $(\alpha = .76)$ among all factors and needs adding several items in order for it to have a good or excellent reliability. As a consequence, an increase in the reliabilities of these factors might lead to an increase in the overall reliability of the translated UGAS.

Attitude towards mathematics is a multidimensional construct that is composed of the following underlying dimensions: confidence, anxiety, value, enjoyment, motivation, usefulness, and parent/teacher expectations (e.g., Aiken, 1974; Fennema & Sherman, 1976; Lim & Chapman, 2013; Ma, 1997; Nisbet, 1991; Richardson & Suinn, 1972; Tapia & Marsh, 2004). Analogous to attitude towards mathematics, the construct of geometry attitude is concerned with the aforementioned dimensions. However, geometry attitude scales that have been developed thus far measured only two or three components of attitude such as enjoyment, usefulness, and anxiety (e.g, Bulut et al, 2002); motivation and self-confidence (e.g., Duatepe & Ubuz, 2007); enjoyment, value, motivation (e.g, Mogari, 2004); usefulness, confidence, enjoyment (Utley, 2007) and so forth. Similar to the original instrument, the translated version of UGAS focused on the following dimensions: everyday usefulness, future usefulness, confidence, and enjoyment. However, a more comprehensive instrument might be constructed by using additional dimensions such as anxiety, motivation, value, and parent/teacher expectations. By developing a more comprehensive scale, researchers might examine a variety of relationships between various domains of geometry

attitude (e.g., enjoyment of geometry; motivation to do geometry; confidence in geometry; and perceived value of geometry) and geometry achievement or geometry problem solving ability. In a more general sense, the instrument might also be used to determine the relationship between geometry attitude and geometry or mathematics achievement.

The 25-item UGAS might be considered as a useful tool not only for prospective teachers but also for other undergraduate students enrolled in faculties such as science and letters and engineering. This tool can especially be useful for teacher educators in getting to know pre-service teachers' attitudes towards geometry and in highlighting the factors that need to be considered when designing teacher training courses related with geometry. Apart from this, robust geometry knowledge is fundamental for engineering students to achieve success in their programs and later in their career. Thus, instructors who are in charge of engineering students might use this instrument to identify these students' attitudes towards geometry at the very beginning. By this way, they can predict to what extend their students might encounter with difficulties in the geometry related courses and organize the teaching and learning atmosphere as such. Additionally, mathematics education researchers might use this scale as a pretest-posttest instrument to investigate whether a specified geometry instruction can change learners' attitudes towards geometry or not.

Meanwhile, while this instrument proved to be valid and reliable for undergraduate students, it might also be tested for use with middle school and secondary school students. By means of this scale, teachers can gain a general sense of their students' attitudes towards geometry and in turn provide themselves opportunities to design geometry lessons on the basis of student needs.

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Utley Geometri Tutum Ölçeğinin Türkçe Uyarlaması: Geçerlik ve Güvenirlik Çalışması

Atıf:

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Özet

Problem Durumu: Matematik eğitiminde, duyuşsal değişkenler ile bilişsel değişkenler arasında güçlü bir etkileşim bulunmaktadır. Bu etkileşim matematik öğretiminde önemli bir rol oynamaktadır. Son yıllarda araştırmacılar öğrencilerin matematiğe yönelik tutumlarını incelemeye büyük önem vermişlerdir ve matematiğe yönelik tutumun ölçülmesinde birçok ölçme aracı geliştirilmiştir. Bunlardan tutumla ilgili verilerin toplanmasında en yaygın, en objektif ve en etkili olanı tutum ölçekleridir. Matematiğe yönelik tutumun ölçülebilmesi için birçok tutum ölçeği geliştirilmesine rağmen öğrencilerin matematiğe yönelik genel tutumları ile matematiğin içinde yer alan geometri, cebir, olasılık gibi alt dalları arasında farklılıklar olabileceği için bu alt dallara özel tutum ölçeklerine ihtiyaç duyulmaktadır. Bu düşünceden yola çıkarak bu çalışmada Utley Geometri Tutum Ölçeği Türkçe'ye uyarlanmıştır.

Araştırmanın Amacı: Birkaç araştırmada ortaokul ve lise öğrencilerinin geometriye yönelik tutumları ölçmek amacıyla tutum ölçekleri geliştirilse de Türkiye'de ulaşılabilir literatürde üniversite öğrencilerinin geometriye yönelik tutumlarını belirlemek için kullanılabilecek geçerli ve güvenilir bir ölçme aracına rastlanılamamıştır. Ulusal literatürdeki bu boşluk Utley Geometri Tutum Ölçeği'nin Türkçe'ye uyarlanmasıyla giderilmeye çalışılmıştır.

Araştırmanın Yöntemi: Çalışmanın katılımcıları İç Anadolu Bölgesindeki bir devlet üniversitesinde öğrenim görmekte olan 863 lisans öğrencisinden (%56 kız, %44 kız) oluşmuştur. 32 maddeden oluşan beşli likert tipindeki Utley Geometri Tutum Ölçeğinin uluslararası çeviri önerileri dikkate alınarak Türkçe'ye çevrilmiş formu 2010-2011 eğitim öğretim yılının bahar döneminde eğitim fakültesi, fen edebiyat fakültesi ve mühendislik fakültesinde öğrenim gören lisans öğrencilerine uygulanmıştır. Ölçeğin Türkçe versiyonunun yapı geçerliğini test etmek amacıyla 371 lisans öğrencisinden elde edilen veriler SPSS 18.0 paket programı ile açımlayıcı faktör analizine, 379 lisans öğrencisinden elde edilen veriler ise LISREL 8.8 paket programı kullanılarak doğrulayıcı faktör analizine tabi tutulmuştur. Doğrulayıcı faktör analizi sonrası ölçeğin uyarlanmış formu madde analizi ve güvenirlik analizi yapılarak değerlendirilmiştir. Madde analizi, düzeltilmiş madde-toplam korelasyonlarının hesaplanmasıyla ve alt-üst grup ortalamalar farkına dayalı bir yöntemle değerlendirilmiştir. Son olarak, ölçeğin Türkçe formunun güvenirliği Cronbach alfa iç tutarlık katsayılarının hesaplanmasıyla değerlendirilmiştir.

Araştırmanın Bulguları: Açımlayıcı faktör analizi öncesinde verilerin faktör analizine uygunluğu Kaiser-Meyer Olkin (KMO) ve Barlett küresellik testiyle değerlendirilmiştir. 32 maddenin KMO değeri .94 ve Bartlett testi anlamlı bulunmuştur $(\chi^2(496) = 5730.06,\ p < .001)$. Ölçeğin Türkçe formunda hangi maddelerin kalacağını belirlemek amacıyla temel bileşenler analizi ve varimax dik döndürme tekniği kullanılmıştır. Analiz sonucunda birinci faktörün (kendine güvenme) 9 maddeden, ikinci faktörün (hoşlanma) 8 maddeden, üçüncü faktörün (gelecekteki fayda) 4 maddeden ve dördüncü faktörün (günlük hayattaki fayda) 4 maddeden oluştuğu ortaya çıkmıştır. Dört faktörün her birinin açıkladığı varyans değerleri sırasıyla %40.83, %7.62, %5.92 ve %5.11 olarak bulunmuştur. Bu dört faktörün açıkladığı toplam varyans değeri ise toplamda %59.49 olarak elde edilmiştir. Faktörlerin her birinin özdeğeri sırasıyla 10.20, 1.90, 1.48 ve 1.27 olarak bulunmuştur. Utley Geometri Tutum Ölçeği'nin Türkçe formunun faktör yapısını belirlemek amacıyla yapılan açımlayıcı faktör analizi sonuçlarını, doğrulayıcı faktör analizi sonuçları desteklemiştir. Doğrulayıcı faktör analizi sonrasında ortaya çıkan uyum indeksi değerleri $((\chi^2(sd = 269) = 800.73,\ p = 0.00),\ \chi^2 / df = 2.98,\ \text{GFI} = .86,\ \text{AGFI} = .82,\ \text{RMSEA} = .072,\ \text{RMR} = .060,\ \text{SRMR} = .060,\ \text{CFI} = .97,\ \text{NFI} = .96,\ \text{NNFI} = .97,\ \text{RFI} = .95,\ \text{IFI} = .97,\ \text{PNFI} = .86$ ve $\text{PGFI} = .71)$ ölçeğin geçerli bir yapıda olduğunu göstermiştir.

Doğrulayıcı faktör analizi sonrasında ölçeğin Türkçe formundaki maddeler madde ayırt edicilik indeksleri hesaplanarak madde analizi yapılmıştır. Madde ayırt edicilik indeksleri düzeltilmiş madde-toplam korelasyon katsayılarının hesaplanmasıyla ve alt-üst grup ortalamalar farkına ait *t* değerlerinin manidarlığının test edilmesiyle değerlendirilmiştir. Madde-toplam korelasyon katsayılarının her bir madde için .37-.72 aralığında olduğunu ve bu da her bir maddenin iyi çalıştığını ortaya koymuştur. Ayrıca, alt-üst grup ortalamalar farkına ait *t* değerleri her bir madde için .01 düzeyinde anlamlı bulunmuştur. Son olarak, ölçeğin Türkçe formunun güvenirliğini değerlendirmek amacıyla ölçeğin bütününe ve alt boyutlarına ait Cronbach alfa

güvenirlik katsayıları hesaplanmış ve sırasıyla .94, .89, .91, .76 ve .81 olarak bulunmuştur. Bu değerler ölçeğin Türkçe formunun iyi düzeyde bir güvenirliğe sahip olduğunu göstermiştir.

Araştırmanın Sonuç ve Önerileri: Bu çalışmadan elde edilen bulgular, 5'li likert tipindeki 25 maddeden ve 4 faktörden oluşan Utley Geometri Tutum Ölçeği Türkçe formunun lisans öğrencilerinin geometriye yönelik tutumlarını belirlemek için hem eğitimciler tarafından hem de araştırmacılar tarafından kullanılabilecek geçerli ve güvenilir bir araç olduğunu ortaya koymuştur. Bu ölçme aracının geçerlik ve güvenirlik çalışmaları lisans düzeyinde öğrenim gören öğrencilerle gerçekleştirildiğinden ortaokul ve lise öğrencilerinin geometriye yönelik tutumlarının bu araçla ölçülebilmesi için bu öğrenim düzeylerindeki öğrencilerden elde edilen verilerle yeniden geçerlik ve güvenirlik çalışmaları gerçekleştirebilir.

*Anahtar Sözcükler: U*yarlama, geometri, tutum ölçeği, lisans öğrencileri