Development of Mathematics Course Attitude Scale: A Preliminary Study of Validity & Reliability

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Abstract   The aim of this research is to develop a Mathematics Course Attitude Scale to measure high school students' attitudes towards mathematics and to test the validity and reliability of this scale. It is also aimed to reveal whether there are significant differences in school students' attitudes towards mathematics according to their gender and mathematics achievement. This research was conducted with 508 volunteer students (198 female, 310 male) studying in five different high schools. One-dimensional scale consisting of 13 items was obtained. Confirmatory factor analysis showed that one factor solution was acceptable. In addition, the internal consistency and composite reliability of the scale were found to be high. We also found that there was a significant and moderate positive correlation between attitude and achievement. It was seen that the average of the attitude points, according to the gender, was very close to each other and the difference was not significant.

Keywords   Mathematics Course Attitude Scale, Academic Achievement, Gender

1. Introduction

Mathematics is seen as a tool for the meaning of life (Ernest, 1991). It is also considered an essential to create a good future (Yenilmez, 2010). Due to the decisive role of mathematics in human life, the mathematics course has taken its place in education programs from the beginning of the school up to higher education (Baykul, 2002). Mathematics is important for individuals beyond mathematical knowledge to gain high-level thinking skills such as critical thinking, interpretation, practical thinking, problem solving, managing the decision-making process successfully, and academic achievement as well as being an effective determinant of success in social life (Işık, 2007; MEB, 2009; Moral, Köroğlu & Çelik, 2004). Although the things that mathematics have brought to individuals are so well known, It is not a lesson learned in a willing way by students, but it is accepted as an obligation. When it was looked at the research trying to explain the reasons for this, the following are identified as reasons why mathematics lessons are not liked and therefore failed: The fact that the students find the mathematics course as an intangible (Erdem & Young, 2014; Moral, Köroğlu & Çelik, 2004), the deficiencies caused by the teaching style of mathematics (Dursun & Dede, 2004; Soylu & Aydın, 2006), not using of teachers various materials in mathematics courses, (Duatepe-Paksu & Akkuş, 2007), concerns about the mathematics course (Baloğlu, 2001; Peker and Mirasyedioğlu, 2003), mistakes in presentation in mathematics textbooks (İskenderoğlu & Baki, 2011; Semperci & Semerci, 2004), memorization pushing because the central examination system in Turkey encourages students to solve questions by racing over time (Açıkgül, Macit & Çakan, 2015; Baştürk, 2011; Doğan, Sulak & Cihangir, 2002) students are unable to understand and are not informed why they should learn mathematics lessons and what is the benefit of mathematics in daily life (Avcı, Coşkuntuncel & İnandı, 2011).

It is emphasized by Köroğlu and Yeşildere (2004) that mathematics should be only processed to reach the goals of the lesson, making it difficult for the students to transfer the skills they have gained through mathematics to their daily lives. In order to achieve success in mathematics teaching, it is necessary to convince students that mathematics can be used throughout their lives. There is research showing that students' level of mathematics learning is directly proportional to their perceptions of mathematics (Francisco & Maher, 2005; Hare, 1999; Kramarski & Zoldan, 2008). It is well known that one of the important factors affecting the academic achievement of the students is their affective properties, because our brain does not try to learn anything that does not make the emotional connection (Canan, 2015). As in all lessons, achieving success in mathematics course is related to attitudes toward mathematics.

Importance of Attitudes

Individuals feel emotion, something involuntarily, for everything that they encounter in their surroundings, such as objects, events, phenomenon, glances, other individuals etc., as well as anything that comes into their lives. According to the affective neuroscience approach, the brain provides different emotional states by evaluating stimulants (Plotnik, 2009). From this point, it is possible to reach the conclusion that the biologic structures of the individual are inclined to evaluate and develop emotions for all kinds of living or non-living beings. These emotional tendencies developed by individuals are expressed as attitudes (Eagly & Chaiken, 1993; Özgüven, 1994).

As stated by Aronson, Wilson and Akert (2012), attitudes are assessments of individuals about other creatures, objects, or thoughts. Attitudes arise as a result of the experience of the individual in relation to the personality traits and cultural values of the entities, situations, events that interact with them (Oskamp & Schultz, 2005; Titrek, Güneş, & Ölçüm, 2013). Tesser (1993) states that the source of attitude is the genes. The study by Bouchard and Loehlin (2001) also supports the findings of Tesser (1993) that genes influence personality and behavior. According to Mahanta (2012), attitudes are important determinants of an individual's personality. One of the determinants of attitude as well as genetic factors is the social milieu (Nowak, Szamrej, & Latané, 1990; Stedman, 2002). It is emphasized that the social effect, which can be defined as the influence of other people's actions or thoughts on the feelings and thoughts of the individuals, is also the determinant of their attitudes (Wood, 2000). Especially the family, which is the closest vicinity of the individual, in the first year of life, has a great share in the individual's attitudes (Kulik, 2002). The study by Francis (1993) found that mothers had more influence over their children's attitudes than fathers.

Attitudes represent not only the affective orientation of person, but also the cognitive aspects of the individual and show permanent characteristics (Aiken, 2002; Krech & Crutchfield, 1948; Tavşancıl, 2006). Attitudes can be positive and negative, as well as having a great influence on directing the behavior of people. Relevant and accepting behaviors are shown when positive attitudes are exhibit, and irrelevant and refusing behavior are shown when negative attitudes are fed (Farc & Sagarin, 2009; Holland, Verplanken & Knippenberg, 2002; Temizkan, 2008). If it is considered that the behavior of the individual leads the world, and behavior are also determined by the attitude, it is better understood important of attitudes for people and society. In order to reach the desired behavior, the development of attitudes in the direction of desired behavior is an educational necessity. Efforts should be made towards knowing the attitudes of the students and turning them into positive ones in the courses that are aimed to gain the desired behaviors.

In order to be able to direct the attitudes, it should be determined first, and in order to be determined, it should be measured (Tavşancıl, 2006). As discussed above, when one of the main factors of success in mathematics is thought to be the attitude towards the lesson, it is better understood that it is necessary to measure this attitude correctly first in order to transform the attitudes of the students to the positive direction.

Problem Statement and Sub-Problems (Hypotheses)

The aim of this research is to develop a Mathematics Course Attitude Scale to measure high school students' attitudes towards mathematics and to test the validity and reliability of this scale. In the context of classical test theory, validity and reliability studies of this scale have been carried out. It is also aimed to reveal whether there are significant differences in school students' attitudes towards mathematics according to their genders and mathematics achievement.

2. Method

This research is a scale development study.

Method of the Research

In the context of classical test theory, validity and reliability studies of this scale have been carried out.

Population-sampling

This research was conducted with 508 (198 females, 310 male) volunteer students studying in five different high schools located in a Northwestern town of Turkey in 2016-2017 academic year. The students selected by convenient sampling technique.

Data Collection Tools

The first form of the scale was formed by adapting the items of "Biology Course Attitude Scale" developed by Arıcak and Ilgaz (2007) to mathematics lesson. The items were assessed by the co-author of the research and two mathematics educators in terms of content and language. The necessary corrections were made on the scale in the direction of the suggestions. This scale is 5-point Likert-type (strongly disagree 1, disagree 2, undecided (neutral) 3, agree 4, and strongly agree 5) scale with 19 items.

Reliability and Validity of Data

In data analysis, the data set was divided into two parts randomly. The scale was divided into 251 and 257 participants for exploratory and confirmatory factor

analysis. The data were first examined in terms of normality. The absence of skewness> 2 and kurtosis> 7 (West, Finch and Curran, 1995) was considered as normality assumption was met. The extreme values were checked with the Z distribution and the values were found to be between ±3 standard deviations. Then, extreme values and multicollinearity states were examined by performing multiple regression with "subject no" given to participants for extreme values and multicollinearity. It was assumed that the variance increase values were less than 10, the tolerance values were greater than .10 (Field, 2009). We also found that there was no correlation of .90 and above between variables (Çokluk, Şekercioğlu and Büyüköztürk, 2014). EFA was performed by principal components analysis. The critical factor load value was taken as .32 (Büyüköztürk, 2005). Confirmatory factor analysis (CFA) was performed with Maximum Likedhood method and model fit evaluation was done according to χ2 / degrees of freedom (df), CFA, TLI and RMSEA values. The reference values accepted in Table 1 are presented.

Table 1. Acceptable threshold levels

Goodness of Fit Indexes	Values	Meaning	References
χ2 / sd	< 5	(Acceptable fit)	Marh and Hocevar (1985)
	.05 and -	(Excellent fit)	Kline (2005)
	Between .05 and .08	(Good fit)	Browne and Cudeck (1993), Sümer (2000)
RMSEA	Between .05 and .10	(Acceptable fit)	Weston and Gore (2006)
	Between .08 and .10	(moderate fit)	MacCallum, Browne and Sugawara (1996, Akt.:Byrne, 2001)
	.10 and +	(Weak fit)	Browne and Cudeck(1993); Sümer (2000)
TLI	.90 and +	(Good fit)	Brown (2006)
CFI	.90 and +	(Good fit)	Brown (2006)

For convergent validity, it was taken as the reference that the average variance extracted (AVE) was .50 or more (Fornell and Larcker, 1981). As a result of the exploratory factor analysis for the construct validity, the remaining items on the scale were collected and the attitude scores of the individuals were obtained and these were ranked. The scores were grouped in the lower-upper 27%, and the discriminant validity of each item was examined. This was done for both samples. Based on the assumption that there was a positive relationship between attitude and achievement, the relationship between scores of first-semester mathematics course grades and total attitude scores was examined. The grouping of students according to their attitude scores was done with the entire study group. The scores were grouped as low, medium, and high by the way of the lower-upper 27% groups. Differences between the group averages were analyzed by one-way ANOVA. The significance level in the independent samples t-test and one-way ANOVA was taken as .05. The effect size in the ANOVA was calculated with the value of eta-square and it was interpreted as a strong influence with a possible low

between .01 and .05, a moderate between .06 and .13, and a greater than .14 in the direction of Cohen's (1988) suggestions.

Composite Reliability and Cronbach Alpha coefficients were calculated for the reliability of the scale and it was considered to be sufficient to have .70 and over for combined reliability (Bagozzive Yi, 1988), and to be above .60 for Cronbach Alpha (Özdamar, 2004).

3. Findings

In this section, the findings of the research were reported.

Findings Related to Exploratory Factor Analysis (EFA)

The analysis was performed by principal component analysis. The Kaiser-Meyer-Olkin score of the scale was .94 and the Bartlett sphericity test was 2400.032. According to this, factor analysis was continued because the sample consistency was high and the distribution was spherical. The results of the first factor analysis showed that the items were mainly gathered under one factor. It is seen that items 1 and 6 are placed under more than one factor and item 13 is not under the first factor. These items were removed and the analysis was repeated. As a result of the second analysis, a two-factor scale, in which the items were mainly gathered in the first factor, emerged. As the 4th, 11th, and 16th items were loaded under the second factor, they were removed from the scale and the analysis was repeated. As a result of this analysis, a 13-item, one-dimensional scale was obtained and all the results are presented in Table 2.

Table 2. EFA results

	1.PCA Result			2. PCA Result		3. PCA Result
	Components			Components		Component
	1	2	3	1	2	1
m1	.46	.39				
m2	.81			.79		.79
m3	.78			.78		.80
m4	.51	.37		.50	.46	
m5	.74			.75		.76
m6	.42	.40	-.48			
m7	.79			.78		.77
m8	.44	-.32		.45		.47
m9	.64			.64		.62
m10	.82			.82		.84
m11	.39			.39	.44	
m12	.83			.84		.85
m13		.40	.74			
m14	.87			.87		.88
m15	.81			.82		.82
m16	.49	.32		.48	.39	
m17	.57			.57		.57
m18	.64	-.41		.67	-.35	.68
m19	.74			.74		.73

PCA=Principal Component Analysis
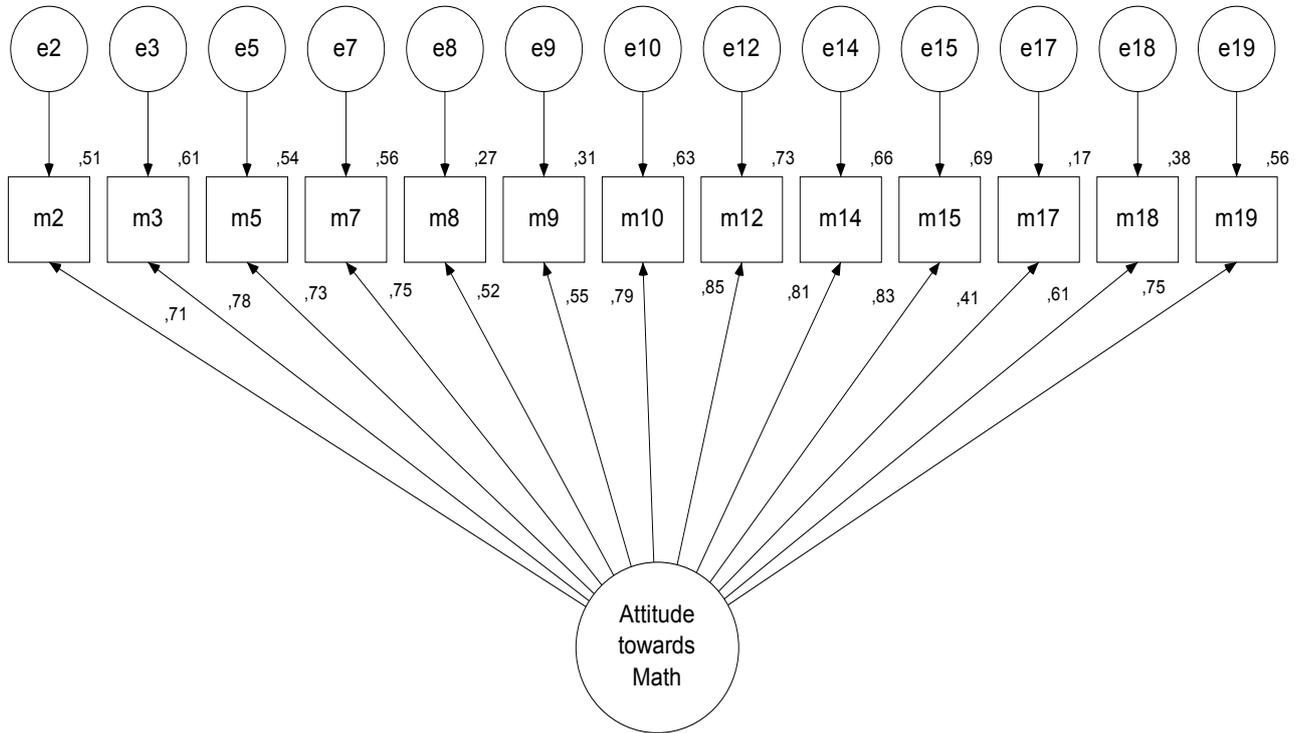
Figure 1. CFA results

Findings Related to Confirmatory Factor Analysis (CFA)

The result obtained from EFA was subjected to CFA. As a result of the analysis, it was seen that one-dimensional scale with factor loads ranging from .41 to .85 had $\chi2$/sd=3.178, CFI=0.913, TLI=0.927, RMSEA=.092 fit indices. It has been accepted that construct validity is in line with the baseline literature.

Convergent, Discriminant and Reliability Tests

The results of the calculations made from the sample for both analyzes of the scale show that the AVE value is above .50 and is within the accepted values. For the discriminant of the scale items, the individuals were ranked according to the total of 13 items, and the lower-upper 27% groups were obtained. In the independent samples t test results, significant results were found in favor of the upper groups in both samples. However, it was found that the corrected total item correlation values were .41-.85 in the EFA sample and .42-.80 in the CFA sample.

In both samples of the scale, the composite reliability and internal consistency reliability coefficients were found to be high.

EFA: Exploratory Factor Analysis, CFA: Confirmatory Factory Analysis, CITC: Corrected Item-Total Correlation, AVE: Average Variance Extracted, CR: Composite Reliability, CA: Cronbach Alpha

Table 3. The results of convergent validity, item discrimination validity and reliability

	EFA Sample					CFA Sample				
	□	□²	□	t	CITC	□	□²	□	t	CITC
m2	.79	.62	.38	20.93	.74	.72	.51	.49	16.73	.71
m3	.80	.63	.37	17.88	.74	.78	.61	.39	17.10	.73
m5	.76	.58	.42	14.21	.71	.74	.54	.46	14.98	.71
m7	.77	.59	.41	18.41	.72	.75	.56	.44	19.00	.74
m8	.47	.22	.78	7.22	.41	.52	.27	.73	8.36	.49
m9	.63	.39	.61	11.04	.57	.55	.31	.69	11.15	.55
m10	.84	.71	.29	19.83	.79	.79	.63	.37	16.71	.76
m12	.86	.73	.27	21.56	.81	.85	.73	.27	18.84	.80
m14	.88	.78	.22	24.64	.85	.82	.66	.34	17.60	.77
m15	.82	.68	.32	21.12	.78	.83	.69	.31	21.32	.79
m17	.57	.32	.68	7.90	.51	.41	.17	.83	7.86	.42
m18	.68	.47	.53	12.17	.63	.61	.38	.62	10.83	.58
m19	.73	.54	.46	16.67	.68	.75	.56	.44	20.82	.74
AVE	.56					.51				
CR	.94					.93				
CA	.93					.93				

Relationship between Mathematics Attitude and Academic Achievement

In order to support the discriminant validity of the scale, it was examined whether there was a significant difference between grade point average of first-semester mathematics course according to the attitudes of the students. Results are presented in Table 4.

Table 4.   Results of ANOVA related to GPA differences according to level of attitudes

Attitude Level	N	Mean	Standard Deviation	95% Confidence Internal for Mean		F	p	Difference	η²
				Lower Bound	Upper Bound				
Low	126	41.27	18.62	37.99	44.55			High > Middle	
Middle	200	50.50	16.86	48.15	52.85	56.61	.00	High > Low	.18
High	140	63.14	17.45	60.23	66.06			Middle > Low	

As the level of attitude increases according to the results of the analysis, the grade point averages of students increases. As a result of the analysis, this increase was found to be highly significant. LSD test revealed significant differences between levels when looking at the source of difference.

Students' Attitudes towards Mathematics Course According to Their Gender

In this research, the relationship between the attitude toward mathematics course with mathematics success and the distribution of attitude according to gender were examined. As a result of the analysis, there was a moderately positive significant relationship between attitude and achievement ($r = .44$, $p < .05$). When Table 5 is examined, it is seen that the attitude point averages are very close to each other and the difference between genders is not significant.

Table 5.   Independent sample t test results for attitude towards mathematics lesson according to gender

Gender	N	Mean	Standard Deviation	t	df	p
Female	178	39.49	12.19			
Male	288	38.24	12.88	1.04	464	.30

4. Discussion

The aim of this research is to develop attitude scale towards mathematics lesson. Validity and reliability analyses of the scale were calculated and the attitudes of high school students were compared according to academic achievement and gender. In the process of developing the scale, exploratory and confirmatory factor analyses were performed for construct validity. Convergent validity, item-discrimination validity and Cronbach alpha were also calculated. All findings were found to be satisfactory.

The Kaiser-Meyer-Olkin value of scale developed for the study was found to be .94. It is accepted that factor analysis can be applied when the value of Kaiser-Meyer-Olkin is higher than .60 (Büyüköztürk, 2005). The Barlett Test value is found to be 2400.03 (p <.00), indicating that the items of the scale can be factored (Tavşancıl, 2006). From the results of the Kaiser-Meyer-Olkin and Barlett test, the factor loads of the scale were examined. As a result of calculating the factor loads, it appears that the factor loads of the items vary

between .47 and .88. It explains the moderate validity when the item factor loadings are between .30 and .60 and explains high-level validity when they are between .30 and .60 (Erkuş, 2012; Kline, 2005). When this is considered, it can be said that the items of the developed scale are accepted as valid at moderate and high level.

CFA results support the finding of EFA. In the one dimensional structure of the scale, lower and higher values of the highest and lowest factor loadings are composed of the same items in the EFA and CFA. It can be said that CFA is compatible with EFA structure when it is considered that the study group is divided into two. On the other hand, only the RMSEA values from the four criteria based on CFA results indicate moderate level concordance. From this point of view, it can be said that the model is correctly constructed. When we look at the AVE values to support EFA and CFA results, it can be said that they are at the lower limit of the literature. However, the closeness of the values obtained from EFA and CFA loads is considered as a consistency for construct validity. Reliability values in the study are above the recommended values in the literature. Both groups show that the results are above .90. In this respect, it can be stated that reliability of the scale is high.

In this study, data reveal that academic achievement increases when positive attitudes towards the mathematics increases. When the literature is examined, it is seen that there is research which supported the findings of this study. The study by Yücel and Koç (2011) found that the high school students' attitude towards mathematics was 16% effective in their success. According to the findings of the study conducted by Savaş, Taş and Duru (2010), it is seen that the beliefs of the students to be successful in mathematics course affected the mathematical achievements. There are many studies in the literature that support the findings of this research, indicating that the attitudes of students towards mathematics lessons have affected academic achievement (Akın, 2002; Bulut, Yetkin & Sazak, 2002; Georgiou, Stavrinides & Kalavana, 2007; Kadijevich, 2008; Kanbolat, Bekdemir & Baş, 2011; Ma, 1997; Ma & Kishor, 1997; Ma & Xu, 2004; Mahanta & Islam, 2012; Minato, & Yanase, 1984; Peker & Mirasyedioğlu, 2003; Şentürk, 2010; Reyes, 1984; Reynolds & Walberg, 1992).

In this study, there was no significant difference between math attitude scores of males and females. According to the study done by Dursun and Dede (2004), teachers suggest that gender does not have significant effect on

mathematical achievement. There are also some other studies in the literature that the attitudes of students towards mathematics do not change significantly according to gender (Bulut, Yetkin & Sazak, 2002; Çelik & Ceylan, 2009; Georgiou, Stavrinides & Kalavana, 2007; McGraw, Lubienski, & Strutchens, 2006; Yücel & Koç, 2011) Hyde, Fennema, Ryan, Frost and Hopp (1990) emphasizes that students are influenced by attitudes regardless of gender, and gender is not a determining factor here.

Contrary to findings of this research, some studies are in the literature indicating that female students' attitudes towards mathematics are more negative than male students (Frost, Hyde & Fennema 1994; Gunderson, Ramirez, Levine & Beilock, 2012; Tocci & Engelhard Jr, 1991).There are also some other studies in the literature that show that female students have more positive attitudes towards mathematics than male students (Akdemir, 2006; Çelik & Bindak, 2005; Linn & Kessel, 1996; Şentürk, 2010; Yenilmez & Özabacı, 2003; Yılmaz, 2006).

5. Conclusions

Data reveal that preliminary analyses for validity and reliability of the scale are satisfactory. The scale is unidimensional and consists of 13 items. We also found that positive attitude towards math had significant effect on math achievement while there was no significant difference between math achievement scores of males and females.

Recommendations

The scale can be tested on different samples.

The scale can be translated into different languages and used in different countries to test invariance.

The relationship between attitude towards mathematics course and different variables can be examined by using the scale.

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