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Investigation of Middle School Students' Attitudes towards Science, Technology, Engineering and Mathematics (STEM) Education and Determination of the Predictors

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ABSTRACT The purpose of the current study is to investigate middle school students' attitudes towards Science, Technology, Engineering, and Mathematics (STEM) education and to determine the predictors of these attitudes. The study was designed according to the relational survey model, one of the quantitative research designs. The sample of the study is comprised of 408 middle school 6th, 7th, and 8th-grade students. The data of the current study were collected using a STEM-oriented attitude scale. An independent samples t-test, one-way variance analysis, and stepwise multiple regression analysis were used to analyze the collected data. As a result of these analyses, it was determined that the students' attitudes towards STEM vary significantly depending on the students' gender, grade level, participation in in-school and out-of-school social activities, science and mathematics achievement. The most effective three predictors of STEM were found to be science achievement, being a 6th grader, and being female. The state of being female was found to be negatively correlated with the prediction of the attitudes towards STEM. As a conclusion of the study, suggestions were made to eliminate gender-based differences in STEM attitudes, increase STEM activities in upper grades, and for career planning.

Keywords STEM, Attitude, Middle school student, Predictors

1. INTRODUCTION

Training individuals having 21st-century skills can be seen as a prerequisite for struggling with today's competitive conditions, producing technology, and ensuring economic growth and well-being. In particular, to strengthen education for innovation, more people should be directed to the fields of science, technology, engineering, and mathematics (OECD, 2018). Implementation of an interdisciplinary approach such as STEM education has been on the agenda of many countries such as the United Kingdom, Australia, Ireland, Norway, Germany, Sweden, Denmark, particularly in the past decade (Bybee, 2010a; Ejiwale, 2012; Gonzalez & Kuenzi, 2012).

STEM education can be defined as the integrated teaching of the four disciplines by establishing connections between science, technology, mathematics, and engineering (Sanders, 2009; Smith & Karr-Kidwell, 2000). STEM education makes it possible for individuals to reach the information they need, to gain skills that can meet their daily needs with the information they have reached, and to be trained in a multidimensional manner in different fields (Yıldırım, 2016). In other words, it is believed that well-qualified and well-equipped individuals will be trained with STEM education (Turner, 2013). It is also thought that STEM education will enable countries to develop technologically and economically (Bybee, 2010b; Bybee, 2013; Fan & Ritz, 2014; West, 2012). Seen from this perspective, the importance of STEM education is highly apparent. When the national literature is examined in Turkey, it is seen that a great emphasis has been put on the importance and necessity of STEM education (Akgündüz et al., 2015; Çorlu, 2014).

While Çorlu (2014) emphasized that quality STEM manpower is needed to increase Turkey's innovation capacity, Akgündüz et al. (2015) stated that Turkey has to train an innovative generation with 21st-century skills and feels interested in STEM fields. The STEM education report of the Ministry of Nastional Education (2016)

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strongly emphasized that STEM education is very important for Turkey and should be put into effect without delay. This report also emphasized that students should be made interested in STEM fields and directed to professions related to these fields. A study conducted in Korea stated that STEM studies had increased students' interest in STEM fields over time, but although students' interest has increased, they do not prefer to choose STEM-related professions (Jon & Chung, 2013). This indicates that students' interest in STEM fields does not directly cause them to prefer a career in STEM fields and that other factors such as attitude, ability, personal characteristics, and employment opportunities may also have a mediating effect. Attitudes towards STEM education can also be seen as one of these factors.

Attitude towards STEM education is defined as the behaviors individuals are expected to display in STEM fields (Yıldırım, 2016). As can be understood from its definition, the attitude towards STEM is reflected in the behaviors. On the other hand, students' attitudes towards science and mathematics are considered among the most critical factors affecting their success in these fields (Abell & Lederman, 2007; OECD, 2007; Oral & McGivney, 2011). With the determination of the attitude towards STEM education, especially at young ages, it is possible to shape the education to be given to students accordingly and to direct students to STEM-centred professions. It is thought to be essential to investigate students' attitudes towards STEM education and the variables that affect these attitudes in this context. There are some studies conducted to determine attitudes towards STEM in the related literature (Aydın, Saka, & Guzey 2017; Gülhan & Şahin, 2016; Gündüz & Tarhan, 2017; Mahoney, 2009; Sivrikaya, 2019; Unfried, Faber, Stanhope, & Wiebe, 2015). In the current study, investigation of middle school students' attitudes towards STEM education concerning the variables of students' grade level, gender, participation in in-school and out-of-school social activities and math and science achievement and determination of the predictors of these attitudes are believed to make contributions to the relevant literature.

Working with a younger age group like middle school students in the current study has a special value since this period represents the first years when individuals' career awareness begins to form. The literature generally reported that as the grade level increases, students' attitudes towards STEM become more negative (Karakaya & Avgın, 2016; Unfried, Faber, & Wiebe, 2014). This indicates that something should be done for students to choose STEM professions in their career plans.

It is known that there are gender differences in attitudes towards STEM and career choices in STEM fields. In a report prepared by UNESCO (2017), it was stated that the rate of women in STEM-related fields in higher education is 35%. The reason for gender differences in STEM fields is explained as the social, cultural, and gender norms that shape the identities, beliefs, behaviors, and choices of women and men. As in other countries that strive to achieve gender equality in STEM fields, some projects are made in Turkey. For example, the "Honey Bees Becoming Engineers" project is carried out in cooperation with Ford Otosan, one of the important automotive industry institutions, the Ministry of National Education and Flying Broom Women's Communication and Research Association. Within the scope of the project, city visits called Hive Days were made, and in 22 provinces, the engineering profession was introduced to a total of 4535 students, 2668 of whom were women (URL-1). As a result, gender should be investigated to develop a positive attitude towards STEM and direct them to make a career in these fields.

It is aimed at students who are expected to acquire 21st-century skills to produce solutions to daily life problems with STEM education. In this connection, students' participation in social activities inside and outside the school on the attitude towards STEM education is curiosity. Finally, investigation of the effect of the achievement in math and science courses on the attitudes towards STEM education based on the relationship between the attitudes towards mathematics and science courses and the academic achievement in these courses (Oral & McGivney, 2011) will provide essential data for mathematics and science curriculums.

In this connection, the current study investigates middle school students' attitudes towards STEM education and determines these attitudes' predictors. To this end, answers to the following sub-problems were sought: 1) Do middle school students' attitudes towards STEM vary significantly depending on; gender, grade level, participation in out-of-school social activities, participation in in-school social activities, math achievement, science achievement?. 2) What is the extent to which gender, grade level, participation in out-of-school and in-school social activities, and math and science achievement together predict middle school students' attitudes towards STEM?

2. METHOD

2.1 Research Model

The current study aiming to investigate middle school students' attitudes towards STEM and to determine the predictors of these attitudes employed the relational survey model. Relational survey studies are conducted to determine the relationship between two or more variables without any treatment to the participants without taking the variables under control (Fraenkel & Wallen, 2009). Through relational survey studies, it is possible to determine the differences between groups or the predictor relationships between the variables.

Table 1 Some demographic features of the participants

Variables	Groups	Frequency	%
Gender	Male	206	50.5
	Female	202	49.5
Grade level	6th grade	173	42.4
	7th grade	107	26.2
	8th grade	128	31.4
Participation in out-of-school social activities	Yes	193	47.3
	No	215	52.7
Participation in in-school social activities	Yes	156	38.2
	No	252	61.8
Math achievement	Low	60	14.7
	Medium	180	44.1
	High	168	41.2
Science achievement	Low	40	9.8
	Medium	132	32.4
	High	236	57.8

2.2 Population and Sample

The current study population consists of 2542 6th, 7th, and 8th-grade students attending 9 state middle schools in a city located in Turkey's Western Black Sea region. According to Cohen, Manion, and Morrison (2018), while determining the sample size, the confidence level should be taken as 95%, and the confidence interval should be taken as 5%; thus, the current study's sample size was determined to be 333. In selecting the participants, the convenience sampling method, one of the non-probability sampling methods, was used. In the convenience sampling method, the researcher starts constructing the sample with the most easily reachable respondents (Cohen, Manion & Morrison, 2018). As a result, 553 middle school students volunteering to participate in the current study constitute the study sample. Of the 553 students, 145 were discarded from the study as they left many items not responded, and as a result of the outlier and missing data analyses. As a result, the analyses were conducted on the data collected from 408 students.

The variables included in the current study are gender, grade level, participation in in-school and out-of-school social activities, math achievement, and science achievement. Information about the demographic features of the students participating in the current study is given in Table 1. The distribution of the participating students across genders and grade levels seems to be balanced. Of the participating students, 47.3% stated that they regularly participate in out-of-school social activities while 52.7% stated that they do not, and while 38.2% of them stated that they participate in in-school social activities, 61.8% stated that they do not. When the students' math and science achievement is examined, it is seen that more than half of them are highly successful in science. In the classification of the students' achievement, the five-point classification system used in Turkey [poor (1), okay (2), medium (3), good (4), very good (5)] was taken as reference, and thus a three-point categorization was constructed (poor, okay=*low*, medium=*medium,* good, very good=*high*).

2.3 Data Collection Tool

The current study data were collected by using the Scale of Attitudes towards STEM developed by the Friday Innovation in Education Institute (2012) and adapted to Turkish by Özcan & Koca (2018). The scale is a five-point Likert scale consisted of 37 items and 4 factors. The adaptation study of the scale into Turkish was conducted by Özcan & Koca (2018) on 1323 middle school 6th, 7th, and 8th-grade students attending middle schools in three cities located in different Turkey regions. In the study, the Cronbach's Alpha coefficient was calculated to be .91 for the whole scale, .86 for the math factor, .87 for the science factor, .86 for the engineering and technology factor, and .88 for the 21st-century skills factor. In this way, the validity and reliability of the scale were established. The lowest score to be taken from the scale is 37, while the highest score is 185.

Cronbach's Alpha (α) reliability coefficient was calculated for the whole scale and its sub-factors in the current study. For the whole scale, the Cronbach's Alpha (α) coefficient was found to be .91, while it was found to be .89 for the math factor, .87 for the science factor, .83 for the engineering and technology factor, and .86 for the 21st-century skills factor. Thus, as the Cronbach's Alpha internal consistency coefficients were found to be in the range of $.80 \leq \alpha < 1.00$ for the whole scale and it is all sub-dimensions, it can be argued that the scale is highly reliable in this sample (Pallant, 2016).

2.4 Data Analysis

Before analyzing the data collected from the Scale of Attitudes towards STEM, the normality assumption was tested to understand whether the variables are distributed normally. One criterion to satisfy the normality assumption is that the skewness and Kurtosis coefficients should be between -1 and +1 (Morgan, Leech, Gloeckner & Barrett, 2004). As a result of the calculations made in this context, mean scores and standard deviations obtained for the whole scale and its sub-dimensions are given in Table 2. The skewness and Kurtosis values for the whole scale and its sub-dimensions are between -1 and +1. Thus, it can be said that the data distributed normally. The lowest mean score was obtained from the scale's mathematics sub-dimensions from among the sub-dimensions of the scale on ($\bar{x}_{Mat.}$= 28.26), while the highest mean score was obtained from the 21st-century skills sub-dimension ($\bar{x}_{21stskills.}$= 28.26). The mean score obtained from the whole scale was found to be $\bar{x}_{STEM}$=135.95.

Independent samples t-test was used to determine whether the mean scores are taken from the whole scale and the sub-dimensions vary significantly depending on gender, participation in out-of-school social activities, and participation in in-school activities. One-way variance analysis (ANOVA) was used to determine whether the mean scores vary significantly depending on grade level and math and science achievement. The analyses were interpreted by taking the significance level as .05 and based on percentages, frequencies, means, and standard deviations. Cohen’s d statistics calculated to determine the extent to which the significant difference is affected by the mean difference. When the Eta squared effect size was found to be .01 then it was considered to be a small effect size; when it was found to be .06, then it was considered to be a medium effect size, and when it was found to be .1, then it was considered to be a large effect size (Cohen, 1988). For the predictor analysis, the stepwise multiple regression analysis was used. While the study's categorical variables were included in the regression analysis by being coded as “dummy variables,” the continuous variables were included in the analysis with their original values. Information about the dummy coding of all the variables included in the analysis is given in Table 3.

In the multiple regression analysis, the assumptions of a normal distribution, linearity, constant variance, absence of autocorrelation, and absence of multicollinearity between independent variables were tested (Kalaycı, 2009). The relationships between standardized estimated values and non-standardized error values were examined with graphs (Figure 1 and Figure 2) for the normality and linearity assumptions. According to Figure 1, it can be argued that the histogram established for the standardized predicted values and normal distribution curves shows a distribution converging to the normal, and according to Figure 2, it can be argued that there is a linear and positive correlation between the variables.

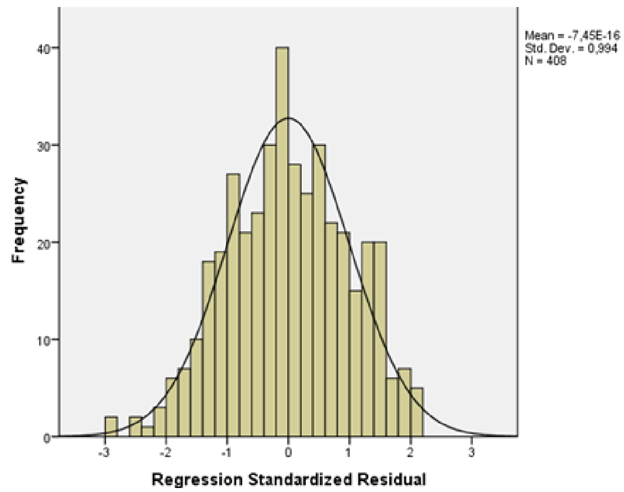

Figure 1 Linearity distribution of STEM

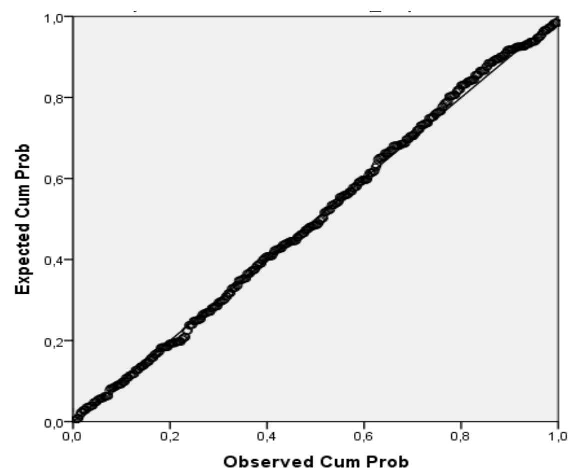

Figure 2 Linearity distribution of STEM

When the indicators of multicollinearity between the predictor variables were examined, tolerance values were found to be ranging from 0.337 to 1.00, and variance inflation factor (VIF) values were found to be varying between 1.00 and 2.969, and the highest condition index (CI) value was found to be 8.47. According to Pallant (2016), to be able to talk about multicollinearity problems in analysis, the VIF value must be smaller than 10, and the tolerance value must be bigger than 0.10. Thus, it can be

Table 2 Mean scores and standard deviations for the whole scale and its sub-dimensions

Factors	N	Min.	Max	$\bar{x}$	SS	Skewness	Kurtosis
Factor 1: Mathematics	408	8.00	40.0	28.26	8.435	-.327	-.932
Factor 2: Science	408	11.00	45.00	32.38	7.987	-.121	-.809
Factor 3: Engineering and Technology	408	11.00	45.00	32.22	7.753	-.330	-.538
Factor 4: 21st century skills	408	15.00	55.00	43.08	8.128	-.667	.414
STEM	408	71.00	185.000	135.95	23.398	-.059	.665

Table 3 Coding of dummy variables

Categorical variables	Level	Dummy variable	Coding	Categories kept outside
Gender	1. Male 2. Female	Gender	Female:1 Male:0	Male
Grade level	1. 6th grade 2. 7th grade 3. 8th grade	Grade6 Grade7	Grade6:1 Grade7:0 Grade6:0 Grade7:1	8th grade
Participation in out-of-school social activities	1. Yes 2. No	$Ouf\text{-}of\text{-}school_{yes}$	Yes:1 No:0	No
Participation in in-school social activities	1. Yes 2. No	$In\text{-}school_{yes}$	Yes:1 No:0	No
Math achievement	1. Low 2. Medium 3. High	Mat_{medium} Mat_{high}	Medium:1 High:0 Medium:0 High:1	Low
Science achievement	1. Low 2. Medium 3. High	$Science_{medium}$ $Science_{high}$	Medium:1 High:0 Medium:0 High:1	Low

Table 4 Results of t-test conducted to determine whether attitudes vary significantly depending on gender

	Gender	N	$\bar{x}$	SS	sd	t	p	Eta square
Factor 1: Mathematics	Male	206	29.03	8.907	406	1.866	.063	--
	Female	202	27.48	7.870				
Factor 2: Science	Male	206	32.98	8.207	406	1.512	.131	--
	Female	202	31.78	7.731				
Factor 3: Engineering and Technology	Male	206	34.69	7.037	406	6.867	.000*	.104
	Female	202	29.70	7.651				
Factor 4: 21st-century skills	Male	206	43.55	8.252	406	1.187	.236	--
	Female	202	42.59	7.990				
STEM	Male	206	140.25	24.358	406	3.816	.000*	.035
	Female	202	131.55	21.567				

said that there is no multicollinearity problem. The Durbin Watson value used to test autocorrelation means that the correlation between error terms is desired to be between 1.5 and 2.5 (Kalaycı, 2009). The Durbin Watson value was found to be 1.78, which shows that there is no autocorrelation. The standardized residual value was found to be between -2.815 and 2.144. Tabachnick & Fidell (2013) stated that this value must be between +3.3 and -3.3. 'Mahalanobis Distance values were found to be ranging from 2.963 and 13.261. This value is lower than 13.82, determined for the minimum independent variable number 13.82 (Pallant, 2016). For Cook's Distance, the max value is 0.022. This value is lower than 1, showing that the data is suitable for regression (Tabachnick & Fidell, 2013).

3. RESULT AND DISCUSSION

3.1 Investigation of the Attitudes towards STEM Education concerning Gender

Independent samples t-test was used to investigate whether the scale and sub-dimensions' attitude scores vary significantly depending on gender. The results of this analysis are presented in Table 4.

Only the mean attitude scores taken from the sub-dimension of engineering and technology were found to be varying significantly depending on gender in favor of the male participants (t=6,687; p<.05). The effect size of the sign was found to be high (Eta square=.104). Similarly, the mean attitude scores taken from the whole scale were found to be varying significantly depending on gender in favor of the male participants (t=3.816; p<.05). Here, the effect size of the sign was found to be low (Eta square=.035).

3.2 Investigation of the Attitudes towards STEM Education concerning Grade Level

Arithmetic means and standard deviations of the attitude scores taken from the Scale of Attitudes towards STEM Education were calculated to grade level. These results are presented in Table 5. The mean scores decrease with increasing grade level. One-way variance analysis (ANOVA) was conducted to determine whether mean attitude scores vary significantly depending on grade level, and the results of this analysis are presented in Table 6.

The students' attitudes vary significantly depending on grade level in all sub-dimensions. Then, to determine the source of the difference found with ANOVA, complementary post-hoc analysis techniques were employed.

Table 5 Frequencies, mean scores and standard deviations to grade level

Grade level	N	Mathematics		Science		Eng.&Tec.		21st cent. skills		STEM	
		$\bar{x}$	SS	$\bar{x}$	SS	$\bar{x}$	SS	$\bar{x}$	SS	$\bar{x}$	SS
6th grade	173	31.56	7.04	33.04	8.32	33.65	7.30	44.71	7.82	142.97	21.94
7th grade	107	27.65	8.17	32.38	7.71	31.67	8.00	42.78	8.29	134.50	23.46
8th grade	128	24.32	8.63	31.50	7.72	30.74	7.86	41.10	7.99	127.66	22.48

Table 6 Results of the variance analysis (ANOVA) conducted to determine whether attitudes vary significantly depending on grade level

		Sum of squares	sd	Mean square	F	p	A significant difference (Tukey)	Eta square
Math	Between-groups	3910.72	2	1955.36	31.61	.000*	6>7, 6>8	.135
	Within-groups	25048.69	405	61.85			7>8	
	Total	28959.41	407					
Science	Between-groups	174.58	2	87.29	1.37	.255	--	
	Within-groups	25790.01	405	63.68				
	Total	25964.59	407					
Eng.& Tec.	Between-groups	666.91	2	333.46	5.68	.004*	6>8	.027
	Within-groups	23795.23	405	58.75				
	Total	24462.15	407					
21st-cen. skills	Between-groups	973.787	2	486.894	7.610	.001*	6>8	.036
	Within-groups	25910.857	405	63.977				
	Total	26884.645	407					
STEM	Between-groups	17542.656	2	8771.328	17.305	.000*	6>7, 6>8	.079
	Within-groups	205286.158	405	506.879				
	Total	222828.814	407					

After ANOVA, to decide which post-hoc multi-comparison technique to use, first Levene's test was used to test the hypothesis of the homogeneity of the variances. After it was determined that the variances are homogenous, Scheffe's multi-comparison technique was used. According to the test results, significant differences were found between the 6th graders and 8th graders in the sub-dimensions of mathematics, science, engineering and technology, and 21st-century skills and the whole scale in favor of the 6th graders ($p<.05$). While in the sub-dimension of mathematics, the effect size was large (Eta square = .135), it was found to be medium in the whole scale (Eta square = .079) and was found to be small in the other sub-dimensions.

3.3 Investigation of the Attitudes towards STEM Education concerning Participation in Out-of-school Social Activities

t-Test was run to determine whether the students' STEM attitude scores vary significantly depending on participation in out-of-school activities. The results of this analysis are presented in Table 7. The mean attitude scores taken from all the sub-dimensions except for the mathematics sub-dimension and the mean attitude scores taken from the whole scale were found to be varying significantly depending on participation in out-of-school social activities in favor of those participating in these activities ($p<.05$) and the effect sizes of these differences are small.

3.4 Investigation of the Attitudes towards STEM Education concerning Participation in In-school Social Activities

t-Test was run to determine whether the students' STEM attitude scores vary significantly depending on participation in in-school activities. The results of this analysis are presented in Table 8. The mean attitude scores taken from the sub-dimension of 21st-century skills and the whole scale vary significantly depending on participation in in-school social activities in favor of those participating in these activities ($p<.05$) and the effect sizes of these differences are small.

3.5 Investigation of the Attitudes towards STEM Education concerning Achievement

Arithmetic means and standard deviations of the attitude scores taken from the Scale of Attitudes towards STEM Education were calculated in relation to achievement. These results are presented in Table 9. The mean scores vary significantly in the whole scale and the sub-dimensions of the scale. One-way variance analysis (ANOVA) was conducted to determine whether there is a significant difference between the mean scores. The results of this analysis are presented in Table 10. The mean attitude scores taken from the sub-dimensions of the attitude scale except for the engineering and technology sub-dimension vary significantly depending on mathematics achievement. To determine the source of the significant differences,

Table 7 Results of the t-test conducted to determine whether attitude scores vary significantly depending on participation in out-of-school activities

	Participation	N	x̄	SS	sd	t	p	Eta square
Factor 1: Mathematics	Yes	193	28.49	8.40	406	.516	.606	--
	No	215	28.06	8.48				
Factor 2: Science	Yes	193	33.28	7.49	406	2.154	.032*	.011
	No	215	31.58	8.35				
Factor 3: Engineering and Technology	Yes	193	33.24	7.23	406	2.542	.011*	.016
	No	215	31.30	8.10				
Factor 4: 21st Century Skills	Yes	193	44.22	7.72	406	2.709	.007*	.018
	No	215	42.05	8.37				
STEM	Yes	193	139.23	22.418	406	2.709	.007*	.018
	No	215	132.99	23.914				

Table 8 Results of the t-test conducted to determine whether attitude scores vary significantly depending on participation in in-school activities

	Participation	N	x̄	SS	sd	t	p	Eta square
Factor 1: Mathematics	Yes	156	29.27	7.93	406	1.899	.058	--
	No	252	27.64	8.69				
Factor 2: Science	Yes	156	32.41	7.91	406	.051	.960	--
	No	252	32.37	8.05				
Factor 3: Engineering and Technology	Yes	156	33.11	7.44	406	1.826	.069	….
	No	252	31.67	7.91				
Factor 4: 21st Century Skills	Yes	156	44.12	7.96	406	2.040	.042*	.01
	No	252	42.43	8.18				
STEM	Yes	156	138.90	22.70	406	2.016	.044*	.01
	No	252	134.12	23.68				

Table 9 Frequencies, mean scores and standard deviations to mathematics and science achievement

Academic Achievement		N	Mathematics		Science		Eng.&Tec.		21st skills	cent.	STEM	
			x̄	SS	x̄	SS	x̄	SS	x̄	SS	x̄	SS
Math.	Low	60	19.35	6.21	29.02	6.54	31.07	6.20	39.75	7.75	119.18	15.61
	Medium	180	28.24	8.19	32.16	7.86	32.50	7.86	42.93	7.61	135.83	22.37
	High	168	31.48	7.00	33.83	8.24	32.33	8.13	44.42	8.48	142.06	23.95
Science	Low	40	22.30	7.96	28.18	6.02	31.35	6.91	40.00	8.55	121.83	18.34
	Medium	132	26.07	8.63	29.92	7.21	31.80	7.17	41.64	7.59	129.43	20.99
	High	236	30.50	7.57	34.47	8.04	32.60	8.20	44.40	8.10	141.98	23.50

complementary post-hoc analysis techniques were employed.

After ANOVA, to decide which post-hoc multi-comparison technique to use, first Levene's test was used to test the hypothesis of the homogeneity of the variances. The Scheffe multi-comparison technique was used for the sub-dimensions of science and 21st-century skills. Moreover, the variances are homogenous. The Dunnet-C multi-comparison technique was used for the sub-dimension of mathematics. As a result, the whole scale where the variances are not homogenous. The obtained findings showed that in all the sub-dimensions and the whole scale, the students with high and medium achievement have significantly higher attitude scores than those with low achievement ($p<.05$). Only in the sub-dimension of mathematics and on the whol were scale were significant dbetween the students having high achievement and medium achievement ($p<.05$). When the effect sizes were examined, effect sizes in the sub-dimension of mathematics (Eta square = .22) and the whole scale (Eta square = .10) were found to be medium, while in all the other sub-dimensions, the effect sizes were found to below.

One-way variance analysis (ANOVA) was run to determine whether the participants' STEM attitude scores vary significantly depending on science achievement, and the results of this analysis are presented in Table 11. The students' attitudes towards STEM vary significantly depending on science achievement in all the sub-dimensions except for the sub-dimension of engineering and technology. To determine the source of the significant

Table 10 Results of the one-way variance analysis (ANOVA) conducted to determine whether the attitude scores vary significantly depending on mathematics achievement

		Sum of squares	sd	Mean square	F	p	A significant difference (Tukey)	Eta square
Math.	Between-groups	6501.12	2	3250.57	58.62	.000	High>Medium High>Low Medium>Low	0.22
	Within-groups	22458.28	405	55.45				
	Total	28959.41	407					
Science	Between-groups	1039.28	2	519.64	8.44	.000	High>Low Medium>Low	0.04
	Within-groups	24925.30	405	61.54				
	Total	25964.58	407					
Eng.& Tec.	Between-groups	96.080	2	48.04	.80	.451	-	
	Within-groups	24366.06	405	60.16				
	Total	2446.14	407					
21st cen. skills	Between-groups	972.33	2	486.17	7.60	.001	High>Low Medium>Low	0.04
	Within-groups	25912.30	405	63.98				
	Total	26884.64	407					
STEM	Between-groups	23140.76	2	11570.38	2.47	.000	High>Medium High>Low Medium>Low	0.10
	Within-groups	199688.05	405	493.06				
	Total	222828.81	407					

differences found in ANOVA, complementary post-hoc tests were initiated.

After ANOVA, to decide which post-hoc multi-comparison technique to use, first Levene's test was used to test the hypothesis of the homogeneity of the variances. Scheffe multi-comparison technique was used for the sub-dimensions of mathematics and 21st-century skills where the variances are homogenous, and the Dunnet-C multi-comparison technique was used for the sub-dimension of science and the whole scale where the variances are not homogenous. The obtained findings showed that in all the sub-dimensions and the whole scale, the students with high achievement have significantly higher attitude scores than those who have a medium and low achievement ($p<.05$). Only in the sub-dimension of mathematics, a significant difference was found between the students having medium achievement and low achievement ($p<.05$). In all the sub-dimensions, effect sizes were found to be small.

3.6 Investigation of the Predictors of the Attitudes towards STEM Education

The data obtained regarding the variables investigated as the factors affecting the attitudes towards STEM education (gender, grade level, participation in out-of-school and in-school social activities, math achievement, and science achievement) were subjected to multiple regression analysis by using the stepwise model, and the results are presented in Table 12. As can be seen in Table 12, the stepwise regression analysis did not include the variables of participation in out-of-school and in-school social activities and math achievement as they did not predict significantly and thus, only the variables of gender, grade level, and science achievement was included in the stepwise regression analysis.

As shown in Table 12, when the predictor variables were included in the regression analysis stepwise, five models were formed. In the first model, while the high science achievement of the student is a predictor variable, in the second model, the 6th-grade variable is added, in the third model female, in the fourth model 7th grade and the fifth model medium level for science achievement are added, and these predictor variables were found to be explaining 21% ($R^2= .211$) of the variance in the predicted variable. The model constructed to explain the attitude scores taken from STEM is significant at the level $\alpha=.05$ ($F=21.470$, $p<.05$). According to the standardized regression coefficient in the fifth model, which explains the variance in the predicted variable to the greatest extent, from among the predictor variables, science achievement is the variable making the greatest contribution to the STEM attitude scores ($\beta=.45$), followed by the 6th-grade level variable ($\beta=.30$), the female variable ($\beta=-.19$), the medium level science achievement variable ($\beta=.17$) and the 7th-grade level variable ($\beta=.13$). The regression equation concerning the prediction of the STEM attitude according

Table 11 Results of the one-way variance analysis (ANOVA) conducted to determine whether the attitude scores vary significantly depending on science achievement

		Sum of squares	sd	Mean square	F	p	A significant difference (Tukey)	Eta square
Math.	Between-groups	3243.63	2.00	1621.81	25.54	.00	High>Medium High>Low Medium>Low	0.11
	Within-groups	25715.78	405.00	63.50				
	Total	28959.41	407.00					
Science	Between-groups	2538.72	2.00	1269.36	21.95	.00	High>Medium High>Low	0.10
	Within-groups	23425.86	405.00	57.84				
	Total	25964.59	407.00					
Eng. &Te	Between-groups	87.61	2.00	43.80	.73	.48	-	
	Within-groups	24374.54	405.00	60.18				
	Total	24462.15	407.00					
21st cen.	Between-groups	1067.34	2.00	533.67	8.37	.00	High>Medium High>Low	0.04
	Within-groups	25817.30	405.00	63.75				
	Total	26884.64	407.00					
STEM	Between-groups	22178.72	2.00	11089.36	22.38	.00	High>Medium High>Low	0.10
	Within-groups	200650.09	405.00	495.43				
	Total	222828.81	407.00					

to the fifth model of the stepwise multiple regression analysis is as follows: $STEM\ ATTITUDE = 117.38 + 21.41 Science_{high} + 14.07 Grade6 + 8.92 Female + 6.92 Grade7 + 8.70 Science_{medium}$

It is known that there are gender differences in the choice of profession related to STEM fields and, therefore, in the education given in STEM fields at universities. In the current study, the attitudes towards STEM education in general and the sub-dimension of engineering and technology were found to be varying significantly depending on gender in favor of the male students. This shows that this difference in individuals' attitudes towards stems starts to emerge in middle school years. Parallel to these findings, Mahoney (2009) and Unfried, Faber, Stanhope, & Wiebe (2015) found that females have weaker attitudes towards the sub-dimension of engineering and technology in STEM. On the other hand, there is a limited amount of research showing that STEM attitudes do not vary significantly depending on gender (Aydın, Saka, & Guzey 2017; Sivrikaya, 2019). The fact that attitudes towards STEM start to vary significantly in favor of males in middle school years shows that works should be carried out for improving students’ attitudes towards STEM at early ages. In this connection, in their study, Gündüz & Tarhan (2017) found that 4th-grade students believe that women should have a job, yet they think that some professions are not for women. This provides clues showing that the main reason for gender-based differences in attitudes towards STEM is the gender perception of society.

In the current study, the middle school students’ attitudes towards STEM education were varying significantly depending on grade level in the sub-dimensions of mathematics, engineering and technology, 21st-century skills, and the whole scale in favor of the 6th graders. In the studies comparing STEM attitudes of students from different grades, it has been concluded that the attitude scores of the lower grades are higher than those of the upper grades (Aydın, Saka & Guzey, 2017; Lamb, Akmal, & Petrie, 2015; Mahoney, 2009; Unfried, Faber, Stanhope, & Wiebe, 2015). One reason for this difference in Turkey can be the centralized higher school entrance exam taken by the 8th graders. In this connection, Çetin & Ünsal (2018) stated that due to the centralized exams, teachers do not implement all the dimensions of the curriculum, they determine their objectives and contents based on these exams, and they tend to deliver their classes through lecturing and to give tests to students. As a result, students can be distanced from STEM activities. Another issue is that in the centralized exams, students' anxiety to perform poorly in the science and math sections of these exams may cause them to feel alienated from these courses. It is necessary to work on the centralized exams used for measurement and evaluation purposes to reduce their negative effects on STEM attitudes.

21st-century students are expected to be versatile and have some skills such as accessing scientific knowledge, producing a scientific product, and thinking analytically (MoNE, 2018). The development of these skills is not possible only through academic development. In this

Table 12 Results of the stepwise multiple regression analysis concerning the variables predicting the attitudes towards STEM

	Model-Predictor variables	B	Std. Error	Beta	t	sig	Partial (r)	Part (R)	R	R^2	F	p
Model 1	Constant	127.66	1.70		74.98	.00			.303	.092	40.921	.000
	Science high	14.32	2.24	.30	6.40	.00	.30	.30				
Model 2	Constant	122.74	1.87		65.63	.00			.394	.155	37.177	.000
	Science high	14.09	2.16	.30	6.52	.00	.31	.30				
	Grade6	11.92	2.16	.25	5.52	.00	.26	.25				
Model 3	Constant	127.04	2.11		60.34	.00			.436	.190	31.532	.000
	Science high	14.64	2.12	.31	6.89	.00	.32	.31				
	Grade6	11.24	2.12	.24	5.29	.00	.25	.24				
	Female	-8.74	2.10	-.19	-4.15	.00	-.20	-.19				
Model 4	Constant	123.93	2.48		49.95	.00			.448	.201	25.272	.000
	Science high	14.69	2.11	.31	6.95	.00	.33	.31				
	Grade6	14.19	2.46	.30	5.76	.00	.28	.26				
	Female	-8.46	2.10	-.18	-4.04	.00	-.20	-.18				
	Grade7	6.44	2.76	.12	2.33	.02	.12	.10				
Model 5	Constant	117.38	3.78		31.02	.00			.459	.211	21.470	.000
	Science high	21.41	3.62	.45	5.92	.00	.28	.26				
	Grade6	14.07	2.45	.30	5.74	.00	.28	.25				
	Female	-8.92	2.09	-.19	-4.26	.00	-.21	-.19				
	Grade7	6.92	2.75	.13	2.51	.01	.12	.11				
	Science medium	8.702	3.814	.17	2.282	.023	.113	.101				

regard, the findings of the current study show that the attitude scores of the students participating in out-of-school and in-school social activities are higher in the sub-dimension of 21st-century skills and the whole scale. Similarly, Yoder (2019) stated that co-curricular activities positively affected students' 21st-century skills development. Also, Dabney et al. (2012) also found a statistically significant relationship between students' participation in school clubs, which can be seen within the scope of social activities and their career interests in STEM professions. Participation in out-of-school and in-school social activities was found to affect the attitudes towards STEM significantly. Thus, students should be encouraged to participate in out-of-school and in-school social activities. Educators should provide such opportunities for students and should prepare the required settings.

In the current study, attitudes of the students who have higher math and science achievement towards STEM were found to be more positive. Parallel to this, Dabney et al. (2012) stated that the students whose science and math grades are higher are more interested in pursuing careers in professions related to science, technology, engineering, and mathematics. In the prediction of STEM attitudes, not mathematics, but science achievement was found to be effective. The science courses being more effective in predicting STEM attitudes can be because STEM activities are done by establishing more connections with science classes' content and activities. In the longitudinal study conducted by Ing (2014), it was determined that mathematics and science achievement from 7th grade to 12th grade are related to STEM career attainment.

Another important finding of the current study is that 21% of the participating students' STEM attitude scores are predicted by the variables of science achievement, being a 6th grader, being female, and having medium science achievement. The three most influential factors in predicting STEM attitude scores were science achievement, being a 6th grader, and being female. These three factors explain 19% of the variance in the students' attitudes towards STEM. Here, being female is in a negative correlation with the attitudes towards STEM.

4. CONCLUSION

The resulting study showed that the attitudes towards STEM education were found to be varying significantly only in the sub-dimension of engineering and technology depending on gender in favor of the male students. Significant differences were found in STEM education attitudes in favor of the student's sixth-graders with participating students in in-school and out-of-school social activities. The students who have higher math and science achievement, attitudes towards STEM education were found to be more positive. The three predictors making the most significant contribution to the students' STEM attitude scores are descending order: high science achievement, being a 6th grader and being female. However, being female is in a negative correlation with the attitudes towards STEM education. In this context, education policies should be developed by considering women's sociological factors to turn to STEM. The reasons for upper-grade students' negative attitudes towards STEM should be investigated, and taken the necessary measures in this direction. The positive effects of these activities on STEM can be utilized by increasing student participation in in-school and out-of-school social activities. In light of the results, while constructing the STEM career plans of students, the students' science achievement, which was found to be a strong predictor of the attitudes towards STEM, can be taken into consideration by teachers.

REFERENCES

Abell, S. K., & Lederman, N. G. (2007). *Handbook of research on science education*. Mahwah, NJ: Lawrence Erlbaum Associates.

Akgündüz, D., Aydeniz, M., Çakmakçı, G., Çavaş, B., Çorlu, M. S., Öner, T. & Özdemir, S. (2015). *STEM eğitimi Türkiye raporu*. Akgündüz, D. ve Ertepınar, H. (Ed). İstanbul: Scala Basım.

Aydın, G., Saka, M., & Guzey, S. (2017). Science, Technology, Engineering, Mathematic (STEM) attitude levels in grades 4th – 8 th. *Mersin University Journal of the Faculty of Education, 13*(2), 787-802. DOI: http://dx.doi.org/10.17860/mersinefd.290319.

Bybee, R. W. (2010a). Advancing STEM education: A 2020 vision. *Technology and Engineering Teacher, 70*, 30-35.

Bybee, R.W. (2010b). What is STEM education?. *Science*, *329*,966. Doi. 10.1126/science.1194998.

Bybee, R. W. (2013). *The case for STEM education: Challenges and opportunities*. Arlington, VA: National Science Teachers.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. Hilsdale. NJ: Lawrence Earlbaum Associates.

Cohen, L., Manion, L., & Morrison K. (2018). *Research methods in education*. (Eighth edition). London:Routledge

Çetin, A., & Ünsal, S. (2019). Social, psychological effects of central examinations on teachers and their reflections on teachers' curriculum implementations. *Hacettepe University Journal of Education, 34*(2), 304-323. doi: 10.16986/HUJE.2018040672

Çorlu, M. S. (2014). FeTeMM eğitimi makale çağrı mektubu [Call for STEM education research in the Turkish context]. *Turkish Journal of Education, 3*(1), 4-10.

Dabney, K. P., Tai, R. H., Almarode, J. T., Miller-Friedmann, J. L., Sonnert, G., Sadler, P. M., & Hazari, Z. (2012). Out-of-school time science activities and their association with career interest in STEM. *International Journal of Science Education, Part B: Communication and Public Engagement, 2*(1), 63-79.

Ejiwale, J. A. (2012). Facilitating teaching and learning across STEM fields. *Journal of STEM Education: Innovations and Research, 13*(3), 87.

Fan, S-C., & Ritz, J. (2014). *International views on STEM education.* http://www.iteea.org/Conference/PATT/PATT28/Fan%20Ritz.pdf sayfasından erişilmiştir.

Fraenkel, J.R & Wallen, N.E (2009). *How to design and evaluate research in education* (7th ed). New York. McGraw-hill.

Friday Institute for Educational Innovation (2012). Middle and High School STEM-Student Survey. Raleigh, NC: Author.

Gonzalez, H. B., & Kuenzi, J. J. (2012). *Science, technology, engineering, and mathematics (STEM) education: A primer*. Congressional Research Service, Library of Congress.

Gülhan, F., & Şahin, F. (2016). The effects of science-technology-engineering-math (STEM) integration on 5th grade students' perceptions and attitudes towards these areas. *Journal of Human Sciences, 13*(1), 602-620.

Gündüz, H. Ç., & Tarhan, S. (2017). The ımpact of gender on primary school students' attitudes towards choosing a profession. *Elementary Education Online*, *16*(3), ss1287-1300 DOI: 10.17051/ilkonline.2017.330258

Ing, M. (2014*).* Gender differences in the influence of early perceived parental support on student Mathematics and science achievement and stem career attainment. *International Journal of Science and Mathematics Education, (2014)12*,1221-1239.

Jon, J. E., & Chung, H. I. (2013). Consultant report securing Australia's future STEM: Country comparisons-STEM Report Republic of Korea. Retrieved Jul 02, 2020 from https://acola.org/wp-content/uploads/2018/12/Consultant-Report-Korea.pdf

Kalaycı, Ş. (2009). *SPSS applied multivariate statistical techniques [SPSS uygulamalı çok değişkenli istatistik teknikleri]*. Ankara: Asil Yayıncılık.

Karakaya, F., & Avgın, S. S. (2016). Effect of demographic features to middle school students' attitude towards FeTeMM (STEM). *Journal of Human Sciences, 13*(3), 4188-4198.

Lamb, R., Akmal, T., & Petrie, K. (2015). Development of a cognition-priming model describing learning in a STEM classroom. *Journal of Research in Science Teaching, 52*(3), 410-437. doi: 10.1002/tea.21200

Mahoney, M. P. (2009). *Student attitude toward STEM: Development of an instrument for high school STEM-based programs*. Unpublished PhD thesis, The Ohio State University.

Ministry of National Education (MoNE, 2016) *STEM education report Directorate General for Innovation and Educational Technologies. [STEM eğitimi raporu. Yenilik ve Eğitim Teknolojileri Genel Müdürlüğü*]. Retrieved from http://yegitek.meb.gov.tr/STEM_Egitimi_Raporu.pdf

Ministry of National Education (MoNE, 2018) *Science curriculum, (Primary and Secondary School 3, 4, 5, 6, 7 and 8. Grades*).[Fen bilimleri dersi öğretim programı, (İlkokul ve Ortaokul 3, 4, 5, 6, 7 ve 8. Sınıflar]. Retrieved from http://mufredat.meb.gov.tr/ProgramDetay.aspx?PID=325

Morgan, G. A., Leech, N. L., Gloeckner, G. W., & Barrett, K. C. (2004). *SPSS for introductory statistics: Use and interpretation*. Psychology Press.

OECD (2007). *PISA 2006: Science competencies for tomorrow's world: Volume 1:* Analysis. OECD Publishing: Paris. http://dx.doi.org/10.1787/9789264040014-en.

OECD (2018). *Strengthening education for innovation. Retrieved Jul 02, 2020 from* https://www.oecd.org/media/oecdorg/satellitesites/stieoutlook/files/policyprofile/STI%20Outlook%2012_%20PP%20HR_Education.pdf.

Oral, I. & McGivney, E. (2011). *The determinants of student performance and achievement in math and science fields in Turkey [Türkiye'de Matematik ve Fen Bilimleri alanlarında öğrenci performansı ve başarının belirleyiciler]i.* İstanbul: Eğitim Reformu Girişimi.

Özcan, H. & Koca, E. (2018). Turkish adaptation of the attitude towards stem scale: a validity and reliability study. *H. U. Journal of Education ,34*(2)*,ss:384-401* doi: 10.16986/HUJE.2018045061.

Özkurt Sivrikaya, S. (2019). Research of high school students' attitudes of stem. *International Journal of Society Researches 11*(18), 914-934. DOI: 10.26466/opus.547459

Pallant, J. (2016). *SPSS survival manual: A step by step guide to data analysis using IBM SPSS* (6th edition). Sydney: Allen & Unwin

Sanders, M. (2009). STEM, STEM education, STEMmania. *The Technology Teacher*, *68*(4), 20-26.

Smith, J. & Karr-Kidwell, P. (2000). The interdisciplinary curriculum: A literary review and a manual for administrators and teachers. http://files.eric.ed.gov/fulltext/ED443172.pdf sayfasından erişilmiştir.

Tabachnick, B.G., & Fidell, L. S (2013). *Using multivariate statistics* (6th edition).Boston: Pearson Education

Turner, K. (2013). *Northeast tennessee educators' perception of STEM education implementation*. Doctoral Dissertation. https://www.dc.etsu.edu/etd/ sayfasından erişilmiştir.

UNESCO (2017). *Cracking the code: Girls' and women's education in science, technology, Engineering and mathematics (STEM).* Retrieved Jul 02, 2020 from https://unesdoc.unesco.org/ark:/48223/pf0000253479.

Unfried, A., Faber, M., & Wiebe, E. (2014). Gender and student attitudes toward science, technology, engineering, and mathematics. *The Friday Institute for Educational Innovation at North Carolina State University* Retrieved Jul 02, 2020 from *https://miso.fi.ncsu.edu/wp-content/uploads/2014/08/AERA-2014-paper-Student-Attitudes-Toward-STEM.pdf*

Unfried, A., Faber, M., Stanhope, D. S., & Wiebe, E. (2015). The development and validation of a measure of student attitudes toward science, technology, engineering, and math (SSTEM). *Journal of Psychoeducational Assessment, 33*(7), 622- 639. doi: 0734282915571160.

URL-1: https://www.rmkmarine.com.tr/bal-arilari-muhendis-oluyor-projesi.html

West, M. (2012). STEM education and The workplace, Occasional Paper series, (4),4.

Yıldırım, B. (2016). A*n examination of the effects of science, technology, engineering, mathematics (stem) applications and mastery learning integrated into the 7th grade science course.* Dissertation, Instıtue of Educational Sciences, Gazi University Ankara. https://tez.yok.gov.tr/UlusalTezMerkezi/tezSorguSonucYeni.jsp

Yoder, B. (2019). *Instructor Perceptions of Extracurricular and Co-curricular Activities on Developing 21st Century Soft Skills in Students*. Doctoral dissertation, Southwest Baptist University.