

STEM in Transition from Primary School to Middle School: Primary School Students' Attitudes

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Abstract

This study aims to examine the STEM attitudes of primary school fourth-grade students who are in the transition period from primary school to middle school. More specifically, this study examines whether the students' attitudes towards STEM significantly differ according to gender, parents' educational background, science achievement, and mathematics achievement. The data obtained from 221 fourth-grade students through the STEM Attitude Scale were analyzed by independent sample t-test and one-way analysis of variance (ANOVA). The research results revealed that students move from primary school to middle school with a high STEM attitude. In this transition, girls' attitudes towards mathematics and boys' towards engineering and technology were higher. The tendency in engineering and technology attitudes differs only in favor of male students but does not differ significantly in parents' educational background, science, and mathematics achievement. While there was no significant difference in general STEM attitudes of the students in terms of gender and mother's education, there was a difference in father's education, mathematics, and science achievement. Following, the research results were discussed, and recommendations for policymakers and practitioners were presented.

Keywords:

STEM Attitude, The Transition From Primary School To Middle School, Fourth-Grade Students, STEM, Attitude, Primary School.

Introduction

In today's 5.0 society, the rapid change in science and technology has enabled countries to change in many areas as health, industry, agriculture, technology (Murphy et al., 2018). In parallel with this change, professions in science, technology, engineering, and mathematics (STEM) fields, which are the sources of innovation of today's digital economies, are predicted to increase visibly compared to other professions. The demand for professions in STEM fields in the USA, for instance, will grow as 8% until 2029 (U.S. Bureau of Labor Statistics, 2021). While the need for experts in STEM fields is constantly increasing, interest in these fields



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is gradually decreasing in developed and developing countries; and preference for these fields as a profession loses popularity (Brophy et al., 2008; Lavonen et al., 2008; National Research Council [NRC], 2011). According to Turkish Industry and Business Association (TUSIAD) estimation, requirement for the STEM-related employment for 2023 will be approximately 1 million in Turkey, and about 31% of this need will not be met (TUSIAD, 2017).

Concerning change in education systems has also become inevitable to meet the increasing professional needs of STEM fields and prepare students for an uncertain future. The uncertainty for today's students requires them to be prepared for and equipped with 21st-century skills such as communication, collaboration, critical thinking, innovation, creativity, and problem-solving. This requirement has led to the adaptation of new and different approaches into education systems. One of these approaches is the STEM education approach (Bybee, 2013). STEM education approach is an educational approach in which the fields of Science, Technology, Engineering, and Mathematics are integrated with daily-life skills (Stohlmann et al., 2012).

The STEM approach has attracted educators as it provides individuals with the skills and competencies necessary for the 21st-century business world (Walton & Johnson, 2015). Also, this approach is preferred to increase students' interest in STEM fields, teach the STEM-related concepts, and improve students' literacy and awareness towards these fields (Sarı et al., 2018). During the period from preschool to higher education, students can decide which fields they like, which fields they are good at, and which professions they will choose (Yıldırım, 2021). Consequently, it is recommended to integrate STEM education in classrooms starting from an early age (NRC, 2011; Yıldırım, 2021) to ensure that students have a positive attitude towards STEM fields (Gonzalez, & Freyer, 2014). STEM education approach is practiced in formal and informal learning environments in many countries such as South Korea, England, and the USA (Smith & White, 2019). There are many important reasons explaining why STEM education is practiced through formal and informal learning. To name a few, STEM education (1) enables school-industry connection, (2) improves 21st century skills (Partnership for 21st Century Skills [P21]), (3) attaches importance to vocational high schools and (4) connects acquired knowledge with daily life (Guzey et al., 2020).

Previous researches have shown that there is a positive relationship between interest in STEM fields and STEM career intention (Christensen & Knezek, 2017). Also, there is a positive relationship between early career

interest in STEM fields and career choice (Crisp et al., 2009). Besides, there is a positive relationship between attitude towards STEM fields and interest in STEM careers (Ciftci et al., 2020; Wiebe et al., 2018). Ciftci et al. (2020) indicated that approximately 43% of the total variance of interest towards STEM careers derived from attitudes towards STEM fields. They reported that attitude towards STEM was an important factor in determining interest in STEM careers. Therefore, it is important to examine students' attitudes towards STEM fields which have an influence on their choices for future careers.

The literature shows that students' attitudes towards STEM careers are not stable in primary and middle schools (Wiebe et al., 2018), and half of the students lose their high attitudes and interest in STEM fields when they reach the 8th grade (Allen, 2016). In this context, studies conducted in recent years (Akif Bircan & Köksal, 2020; Christensen & Knezek, 2017; Ciftci et al., 2020; Karakaya & Avcı, 2016; Koyunlu et al., 2020; Özcan & Koca, 2019; Yerdelen et al., 2016; Yıldırım & Selvi, 2017) have focused on determining the attitudes of middle school students towards STEM fields and their career interests in these fields. However, little is known about what the students' attitudes towards STEM are during the transition from primary to middle school. Particularly, determining the attitudes of primary school 4th-grade students towards STEM fields and examining these attitudes according to different variables can give important clues to policymakers, curriculum developers, teachers, and researchers on STEM education. Relatively, this study aimed to determine the primary school students' attitudes towards STEM, and the following questions are attempted to be answered:

- What are the attitudes of primary school fourth-grade students towards STEM?
- Is there any significant difference in the attitudes of primary school fourth-grade students towards STEM in terms of gender, parents' educational background, mathematics achievement, and science achievement?

Method

Research model

Aiming to determine the attitudes of fourth-grade students towards STEM, the survey model was used in this study. A survey model can be used to analyze the opinions of the participants about an issue or event or their interests, skills, abilities, attitudes, etc. It is used in cases where certain features are desired to be identified (Büyüköztürk et al., 2009).

Participants

Participants were selected according to the purposeful sampling method of non-probability sampling methods. In this sampling, the researcher decides on the sample to be conducted, and in this way, the most suitable sample is selected with the purpose of the study (Balci, 2016). Choosing the most suitable sample in the research provides time and convenience for the people doing the research (Patton, 2002). While determining the participants, we focused on the students with family profiles from lower levels of socioeconomic status and educational background. The convenience sampling method was applied while reaching the participants. The total number of participants is 221 fourth-grade students from one of Turkey's western provinces. Table 1 shows the demographic information of fourth-grade students who voluntarily participated in the study.

Table 1

Demographic Information of Participants

		<i>f</i>	%
Gender	Girl	125	55.6
	Boy	96	43.4
	Total	221	100
Mother's educational background	Primary school	68	30.7
	Middle school	102	46.2
	High school	51	23.1
	Total	221	100
Father's educational background	Primary school	74	33.5
	Middle school	77	34.8
	High school	70	31.7
	Total	221	100
Mathematics achievement	Low	10	4.5
	Middle	72	32.6
	High	139	62.9
	Total	221	100
Science achievement	Low	17	7.7
	Middle	71	32.1
	High	133	60.2
	Total	221	100

Data Collection Tools

Demographic information form and "STEM Attitude Scale" were used as data collection tools in the study. The demographic information form developed by the researchers consisted of students' gender, parents' educational background, mathematics achievement, and science achievement.

"STEM Attitude Scale" was developed by Faber et al. (2013) and adapted into Turkish for primary schools by

Özyurt et al. (2018). The construct validity of the scale was tested by the researchers with confirmatory factor analysis (Özyurt et al., 2018). The scale has 37-items as 5-point Likert-type with 4 sub-dimensions, namely: Mathematics (8), Science (9), Engineering-technology (9), and 21st century skills (11). In the scale adaptation study, the Cronbach Alpha reliability coefficients of Mathematics, Science, Engineering-technology, 21st century skills, and Attitude towards STEM were calculated as .78, .82, .82, .90, and .93 respectively (Özyurt et al., 2018). For this study, Cronbach Alpha reliability coefficients were calculated as .82, .84, .88, .90, and .92, respectively.

Data Collection

The data collection was carried out in 4 stages. Firstly, possible primary schools to conduct the study were decided. Following, fourth-grade classroom teachers working in these schools were determined. Secondly, teachers were contacted by telephone and informed about the research. Eight teachers were willing to support the research. Thirdly, measurement tools were digitized with a Google Form, and the form's URL address was sent to volunteer teachers. Finally, the URL address of the form was shared with the students in virtual classrooms by the teachers. Since the data collection process was in the pandemic period, no face-to-face interviews were held with the teachers, and the data were not collected in the classroom. With the help of teachers, fourth-grade students anonymously filled out the form within two weeks. When the given responses to the form stopped, the data collection was completed and the data analysis was started. Since the form was digital and each question had to be answered, the data were obtained without any errors and losses.

Data Analysis

To determine the statistical tests to be used in the analysis of the data, it was examined whether the data showed a normal distribution or not. Kurtosis and Skewness values of the scores obtained from the subscales and the scale were in the range of -1 +1 (see Table 2), indicating the scores do not deviate excessively from the normal distribution (Hair et al., 2019). With the assumption of normality and homogeneity of variances regarding group scores, data analysis was conducted through independent sample t-test and the one-way analysis of variance (ANOVA) test. In determining the source of the significant difference between the group averages as a result of ANOVA test, Scheffe test was used, since the groups did not have an equal number of participants.

Obtaining significant differences in the data analysis, Cohen's *d* was used to report the effect sizes of these

differences. As Cohen (1992) guided, Cohen's *d* effect sizes were interpreted as small (0.20), medium (0.50), and large (0.80). Eta square (η^2) was used to report the effect sizes related to the significant differences found as a result of ANOVA test, and the values were interpreted as small (0.01), medium (0.06), and large (0.14) effect sizes (Büyüköztürk, 2015). Data analysis was proceeded via SPSS 23 statistical software, taking the significance level as .05.

Results

Students' Attitudes towards STEM

Table 2 shows the descriptive statistics obtained from the STEM Attitude Scale and its subscales. The average scores on the STEM attitude scale were, respectively, "Mathematics" ($M = 32.63, SD = 5.36$, out of 40), "Science" ($M = 36.11, SD = 5.36$, out of 45), "Engineering-technology" ($M = 35.51, SD = 6.13$, out of 45), "21st century skills" ($M = 46.78, SD = 6.15$, out of 55), and "Total" ($M = 151.02, SD = 17.33$, out of 185). All of them were high, indicating that students had a positive learning attitude towards STEM.

STEM Attitude and Gender

Table 3 presents independent t-test results examined if there was any gender difference in the primary school 4th-grade students' STEM attitudes.

As shown in Table 3, a statistically significant difference was identified in "Mathematics" ($t = 2.02, p < .05$) and "Engineering-technology" ($t = 3.48, p < .01$). While the female students' scores ($M = 33.30, SD = 5.35$) on the "Mathematics" were significantly higher than the male ($M = 31.80, SD = 5.29$), the male students' scores ($M = 37.10, SD = 4.87$) on the "Engineering-technology" were significantly higher than the female ($M = 34.3, SD = 6.71$). The Cohen's *d* effect sizes were, respectively, 0.27 and 0.47, suggesting a small and medium effect size. Except for the "Mathematics" and "Engineering-technology" subscales, no other subscales and total scale scores revealed significant differences between the male and female students.

STEM Attitude and Mother's Educational Background

Table 4 shows the descriptive findings and one-way analysis of variance (ANOVA) results of the STEM

Table 2
Descriptive Findings

	N	M	SD	Min	Max	Skewness	Kurtosis
Mathematics	221	32.63	5.36	18	40	-.61	-.26
Science	221	36.11	5.36	20	45	-.32	-.26
Engineering-technology	221	35.51	6.13	18	45	-.36	-.28
21 st century skills	221	46.78	6.15	28	55	-.43	-.24
Total	221	151.02	17.33	100	185	-.21	-.18

Table 3
T-Test Results of Attitude Scale Towards STEM According to Gender

		N	M	SD	df	t	p	Cohen's d
Mathematics	Girl	125	33.3	5.35	219	2.02	0.04	0.27
	Boy	96	31.8	5.29				
Science	Girl	125	36.3	5.42	219	0.72	0.47	0.09
	Boy	96	35.8	5.30				
Engineering-technology	Girl	125	34.3	6.71	219	3.48	0.00	0.47
	Boy	96	37.1	4.87				
21 st century skills	Girl	125	47.2	6.20	219	1.16	0.25	0.15
	Boy	96	46.2	6.07				
Total	Girl	125	151.1	18.30	219	0.06	0.96	0.00
	Boy	96	150.9	16.08				

attitude scale and its subscales, according to the mother's educational background. There was no significant difference in scale and its subscales in terms of mother's educational background. This indicated that mother's educational background did not play a role in STEM attitudes of the students.

Stem Attitude and Father's Educational Background

Table 5 shows the descriptive findings and one-way analysis of variance (ANOVA) results of the STEM attitude scale and its subscales, according to the father's educational background. As seen in Table 5, significant differences were found in "Science" ($F = 9.51, p < .01$) and "Total" ($F = 3.71, p < .05$). The eta-square (η^2) effect sizes were, respectively, 0.08 and 0.03, suggesting a medium and small effect size. No significant father's educational background differences were found in other subscales. This indicated that father's educational background did play a role in STEM attitudes of the students.

The Scheffe test results showed that the difference between the mean scores of the students in "Science" was due to the significant difference among students

whose fathers were high school graduates and primary school graduates ($t = 3.93, p < .01$), and among students whose fathers were high school and middle school graduates ($t = 3.66, p < .01$). Students whose fathers were high school graduates had statistically significantly higher attitudes than students whose fathers were primary ($M = 34.90, SD = 4.73$) and middle ($M = 35.20, SD = 5.53$) school graduates. The Cohen's d effect sizes were, respectively, 0.66 and 0.60, suggesting a medium effect size.

In terms of the difference between the scores obtained from the scale total, the Scheffe test results showed that this difference was due to the difference between the students whose fathers were high school and middle school graduates ($t = 2.48, p < .05$). On the other hand, there was no significant difference between students whose fathers were high school graduates and primary school graduates ($t = 2.25, p > .05$). However, due to the absence of zero value in the 95% CI [-0.71, -0.04], regarding the effect size, it could be accepted that there was a significant difference among these groups in favor of the students whose fathers were high school graduates. Students ($M = 156.00, SD = 17.60$) whose fathers were high school

Table 4
An Analysis of STEM Attitude and Mothers' Educational Background

	(1) Primary School (n = 68)		(2) Middle School (n = 102)		(3) High School (n = 51)		F	p
	Mean	SD	Mean	SD	Mean	SD		
Mathematics	32.0	5.75	32.5	5.22	33.7	5.03	1.49	0.22
Science	35.7	5.32	35.6	5.41	37.6	5.12	2.79	0.06
Engineering-technology	36.0	5.22	34.6	6.72	36.7	5.83	2.46	0.08
21 st century skills	47.9	5.57	46.0	6.58	46.7	5.88	1.86	0.16
Total	152.0	16.9	149.0	17.7	155.0	16.7	2.11	0.12

Table 5
An Analysis of STEM Attitude and Fathers' Educational Background

	(1) Primary School (n = 74)		(2) Middle School (n = 77)		(3) High School (n = 70)		F	p	Scheffe test
	Mean	SD	Mean	SD	Mean	SD			
Mathematics	32.10	5.37	32.20	5.55	33.60	5.07	1.75	0.18	-
Science	34.90	4.73	35.20	5.53	38.30	5.19	9.51	0.00	3>1 3>2
Engineering-technology	35.40	5.30	34.80	7.19	36.40	5.62	1.36	0.25	-
21 st century skills	46.70	5.36	46.40	6.79	47.30	6.24	0.36	0.70	-
Total	149.00	14.20	149.0	19.20	156.00	17.60	3.71	0.03	3>1 3>2

graduates had statistically significantly higher STEM attitudes than students whose fathers were primary ($M = 149.00, SD = 14.20$) and middle ($M = 149.00, SD = 19.20$) school graduates. The Cohen's d effect sizes were, respectively, 0.41 and 0.37, suggesting about medium and small effect size.

STEM Attitude and Science Achievement

This study also examined the role of science achievement in primary school 4th-grade students' STEM attitudes dispositions. Students' science achievement was categorized into three groups; low is within less than 50 points, middle is 50 to 75 points, and high is more than 70 points. Table 6 shows the results of the one-way variance analyses (ANOVA). As shown in Table 6, except for "Engineering-technology" ($F = 1.06, p > .05$), statistically significant differences were identified in "Mathematics" ($F = 13.00, p < .01$), "Science" ($F = 21.90, p < .01$), and "21st century skills" ($F = 12.00, p < .01$), and "Total" ($F = 15.6, p < .01$). The eta-square (η^2) effect sizes were, respectively, 0.11, 0.17, 0.10, and 0.13, suggesting a large effect size. That is, students' science achievement did play a role in STEM attitudes except for the "Engineering-technology" subscale. This also shows that the science and engineering-technology disciplines could not be adequately dealt with in the context of Turkey.

Scheffe test results showed students with high science achievement on the "Mathematics" was statistically higher than those of middle level ($t = 3.96, p < .01$) and low level ($t = 3.93, p < .01$). The Cohen's d effect sizes were, respectively, 0.92 and 0.87, suggesting a large effect size. Similarly, students with high science achievement on the "Science" was statistically higher than those of middle ($t = 6.24, p < .01$) and low ($t = 3.40, p < .01$). The Cohen's d effect sizes were, respectively, 0.92

and 0.87, suggesting a large effect size. In terms of "21st century skills", attitudes of students with high science achievement were statistically higher than the middle ($t = 4.66, p < .01$), and attitudes of students with middle science achievement were statistically higher than low ($t = 3.14, p < .01$). The Cohen's d effect sizes were, respectively, 1.20 and 0.85, suggesting a large effect size. These findings mean that students with high science achievement have higher "Mathematics" and "Science" attitudes than those of middle and low, and as their success in science increases, their attitudes towards the "21st century skills" also increase.

Attitudes of students with high science achievement on the total scale was statistically higher than those of middle ($t = 4.53, p < .01$) and low ($t = 4.10, p < .01$). The Cohen's d effect sizes were, respectively, 0.67 and 1.57, suggesting a medium and large effect size. This means that students with high science achievement have higher STEM attitudes than those of middle and low ones.

STEM Attitude and Mathematics Achievement

This study also examined the role of students' mathematics achievement in primary school 4th-grade students' STEM attitudes dispositions. Students' mathematics achievement was categorized into three groups; low is within less than 50 points, middle is 50 to 75 points, and high is more than 70 points. Table 7 shows the results of the one-way variance analyses (ANOVA). As shown in Table 7, except for "Engineering-technology" ($F = 0.07, p > .05$), statistically significant differences were identified in "Mathematics" ($F = 5.40, p < .01$), "Science" ($F = 4.24, p < .01$), and "21st century skills" ($F = 6.61, p < .01$), and "Total" ($F = 15.9, p < .01$). The eta-square (η^2) effect sizes were, respectively, 0.25, 0.04, 0.06, and 0.12, suggesting a large, small, medium,

Table 6
An Analysis of STEM Attitude and Science Achievement

	(1) Low (n = 17)		(2) Middle (n = 71)		(3) High (n = 133)		F	p	Scheffe test
	Mean	SD	Mean	SD	Mean	SD			
Mathematics	28.80	5.10	31.00	5.46	34.00	4.88	13.00	0.00	3 > 1 3 > 2
Science	33.60	4.64	33.40	4.97	37.90	4.92	21.90	0.00	3 > 1 3 > 2
Engineering-technology	35.30	4.66	34.70	5.36	36.00	6.64	1.06	0.35	-
21st century skills	40.90	6.25	45.90	5.15	48.00	6.16	12.00	0.00	3 > 1 2 > 1
Total	139.00	16.8	145.0	14.20	156.00	17.2	15.6	0.00	3 > 1 3 > 2

Note. Low = less than 50 points; Middle = 50 to 75 points; High = more than 75 points

and large effect size. That is, students' mathematics achievement did play a role in STEM attitudes except for the "Engineering-technology" subscale. This also shows that the mathematics and engineering-technology disciplines could not be adequately dealt with in the context of Turkey.

Scheffe test results showed that attitudes of students with high mathematics achievement on the "Mathematics" were statistically higher than those of middle ($t = 5.79, p < .01$) and low ($t = 6.92, p < .01$). There was also a significant difference in attitudes of students with middle mathematics achievement on the "Mathematics" compared to those of low ($t = 4.22, p < .01$). The Cohen's d effect sizes were, respectively, 0.84, 2.26, and 1.42, suggesting a large effect size. Similarly, attitudes of students with high mathematics achievement on the "21st century skills" were statistically higher than those of middle ($t = 2.72, p < .05$) and low ($t = 2.80, p < .05$). The Cohen's d effect sizes were, respectively, 0.40 and 0.92, suggesting about medium and large effect sizes. On the other hand, there were no significant differences in students' "Science" attitudes ($p > .05$). However, due to the absence of zero value in the 95% CI [-1.34, -0.04] and [-0.62, -0.05], regarding the effect sizes, it could be accepted that attitudes of students with high science achievement on the "Science" subscale were statistically higher than those of middle and low achievement. The Cohen's d effect sizes were, respectively, 0.33 and 0.69, suggesting a small and medium effect size. This means that students with high mathematics have higher "21st century skills" and "Science" attitudes than those of middle and low, and as their success in mathematics increases, their attitudes towards the "Mathematics" subscale also increase.

Attitudes of students with high mathematics achievement on the total scale were statistically higher than those of middle ($t = 3.98, p < .01$) and low ($t = 4.41, p < .01$). There was also a difference in attitudes of students with middle mathematics achievement compared to ones with low achievement ($t = 2.57, p < .05$). The Cohen's d effect sizes were, respectively, 0.59, 1.44, and 0.89, suggesting a medium, large and large effect size. These findings mean that as their mathematics success increases, their STEM attitude also increases.

Discussion

This study aimed to examine the STEM attitudes of primary school 4th-grade students. Particularly, this descriptive study aimed to reveal whether students' attitudes towards STEM significantly differ according to gender, parents' educational background, science, and mathematics achievements.

In terms of general STEM attitudes, results show that students have high STEM attitudes. This finding is in parallel with many studies in the literature (Karakaya & Avgin, 2016; Özcan & Koca, 2019; Yıldırım & Selvi, 2017; Yerdelen et al., 2016). Students' STEM attitudes and interests are high at an early age, but they may decrease over time (Allen, 2016). Since students' attitudes towards STEM affect their early career choices in STEM fields (Brophy et al., 2008), determining it from an early age is necessary.

The results show no significant difference in STEM attitudes of the students in terms of gender. This finding is parallel to many studies (Aydın et al., 2017; Balçın et al., 2018; Brown et al., 2016; Ciftci et al.,

Table 7
An Analysis of STEM Attitude and Mathematics Achievement

	(1) Low ($n = 10$)		(2) Medium ($n = 72$)		(3) High ($n = 139$)		F	p	Scheffe test
	Mean	SD	Mean	SD	Mean	SD			
Mathematics	23.80	4.13	30.50	4.25	34.40	4.91	5.40	0.00	3 > 2 3 > 1 2 > 1
Science	33.20	5.35	35.10	5.11	36.80	5.37	4.24	0.02	3 > 2 3 > 1
Engineering-technology	32.30	5.31	34.80	6.20	36.10	6.07	2.64	0.07	-
21st century skills	42.30	7.12	45.40	5.65	47.80	6.09	6.61	0.00	3 > 2 3 > 1
Total	132.00	15.50	146.0	17.10	155.00	15.9	15.40	0.00	3 > 2 3 > 1 2 > 1

Note. Low = less than 50 points; Middle = 50 to 75 points; High = more than 75 points

2020; Özyurt et al., 2018). Özyurt et al. (2018) found no significant difference between primary school student's attitudes towards STEM and gender. On the other hand, in this study, it was found that girls' attitudes towards mathematics were higher than boys', while boys' attitudes were higher than girls' in engineering and technology. This finding coincides with the results of the research conducted by Ciftci et al. (2020) and Koyunlu Ünlü & Döküm (2020). Similarly, there are studies showing boys are more interested in engineering than girls and the perception that engineering is a more suitable profession for men (Capobianco et al. 2011; Ketenci et al., 2020; Knight & Cunningham, 2004; Yıldırım & Türk, 2018). There are also studies indicating that student's attitudes towards STEM change depending on gender (Christensen & Knezek 2017; Karakaya et al., 2018). These studies show that boys' attitudes towards STEM are higher than girls' (Reinking & Martin, 2018; Legewie & DiPrete, 2014). Gender pressure can be the major rationale for this conclusion (National Science Foundation [NSF], 2003).

When STEM attitudes of the students are examined in terms of parents' educational background, the findings show that students' STEM attitudes do not differ according to their mothers' educational background, but they do in terms of their fathers' educational background. Students whose fathers are high school graduates have higher Science and STEM attitudes than students whose fathers are middle and primary school graduates. Sivrikaya (2019) also has reached a similar finding. Similarly, Fan (2003) has indicated that students' STEM attitudes differ according to parents' educational background. As opposed to these findings, Aydın et al. (2017) have stated no difference in the students' attitudes towards STEM regarding parents' educational background. Families, mothers in particular, with low socio-economic and education level generally work in agriculture and service sectors, so it may have effect on these results.

In terms of students' science and mathematics achievement, the results show that students' mathematics, science, 21st century skills, and STEM attitudes significantly differ, except for engineering and technology. Also, the findings show that as students' science achievement increases, their 21st century skills attitudes increase; as students' mathematics achievement increases, mathematics and STEM attitudes increase significantly. Previous studies show that students' academic achievements positively affect their attitudes towards STEM (Karakaya et al., 2018; Olivarez 2012). There is a positive relationship between students' science and mathematics achievements and their attitudes towards these courses (Liu et al., 2011). Previous research results are consistent with the results of the study.

Conclusion

The research reveals that students move from primary school to middle school with a high STEM attitude. In this transition, girls' attitudes towards mathematics and boys' towards engineering and technology are seemingly higher. The tendency in engineering and technology attitudes differs only in favor of male students but does not differ significantly in parents' educational background, science and mathematics achievement. While there is no significant difference in STEM attitudes of the students according to gender and mothers' educational background, there is a difference in fathers' educational background, mathematics and science achievement.

Implications for Policy and Practice

If the high level of attitude in the transition to middle school can maintain during the secondary school period, students' career preferences towards STEM fields may increase. For this reason, it is recommended to make changes in middle school curricula. Instructional interventions depending on the curriculum changes may include STEM-based design-oriented activities in which knowledge turns into products.

It is striking that although the girls have high attitudes towards mathematics; their attitudes towards engineering and technology are low. If there is no intervention in the primary school period, it may continue during the middle and high school periods (Ketenci et al., 2020). Therefore, instructional activities can be organized to increase girls' engineering and technology attitudes. With after-school and summer camp activities for girls, their design and production skills can be improved. Raising girls' engineering and technology attitudes at this age can positively affect career choices in forward-looking engineering and computer science fields.

Another important result of the study is that there is no significant difference in engineering and technology attitudes of students with high mathematics and science achievements from other levels of education. It may indicate that STEM applications are not sufficiently implemented in primary school. Updating primary school curricula to include STEM activities can both increase students' existing STEM attitudes and make it easier to increase girls' positive attitudes towards engineering and technology.

Limitations

This study has some limitations. The first limitation of the study is that the number of fourth-grade primary school students is limited; therefore, the generalizability

is low. This means that findings cannot be interpreted to reflect all fourth-grade primary school students in Turkey. However, research findings will make a sense in understanding fourth-grade primary school students' attitudes towards STEM. The second limitation of the study is that when examining the students' attitudes towards STEM, the variables were gender, parents' educational background, science achievements, and mathematics achievements. Different variables can be used in future studies. The third limitation of the study is that it is a quantitative study, and STEM attitudes of students can be investigated in more depth with qualitative studies.

References

- Akif Bircan, M., & Köksal, Ç. (2020). Investigation of STEM attitudes and STEM career interests of gifted students. *Turkish Journal of Primary Education*, 5(1), 16–32.
- Allen, A. (2016). *Don't fear STEM-you already teach it*. School Age/ After School Exchange, September/October 56–59.
- Aydın, G., Saka, M., & Guzey, S. (2017). Science, technology, engineering, mathematic (STEM) attitude levels in grades 4th- 8th. *Mersin University Journal of the Faculty of Education*, 13(2), 787-802. <http://dx.doi.org/10.17860/mersinefd.290319>
- Balcı, A. (2016). *Sosyal bilimlerde araştırma yöntem teknik ve ilkeleri*[Research methods, techniques and principles in social sciences]. Pegem Akademi.
- Balçın, M., Çavuş, R., & Yavuz Topaloğlu, M. (2018). Investigation of secondary school students' attitudes towards STEM and their interest towards professions in STEM fields. *Asian Journal of Instruction*, 6(2), 40-62.
- Brophy, S., Klein, S., Portsmouth, M., & Rogers, C. (2008). Advancing engineering education in P-12 classrooms. *Journal of Engineering Education*, 97(3), 369–387. <https://doi.org/10.1002/j.2168-9830.2008.tb00985.x>.
- Brown, P. L., Concannon, J. P., Marx, D., Donaldson, C. W., & Black, A. (2016). An examination of middle school students' stem self-efficacy with relation to interest and perceptions of STEM. *Journal of STEM Education: Innovations and Research*, 17(3), 27-38.
- Bybee, R. W. (2013). *The case for STEM education: Challenges and opportunities*. NSTA Press.
- Büyüköztürk, Ş., Kılıç Çakmak, E., Akgün, Ö. E., Karadeniz, Ş., & Demirel, F. (2009). *Bilimsel araştırma yöntemleri* [Scientific research methods] (3rd ed.). Ankara: Pegem Akademi.
- Büyüköztürk, Ş. (2015). *Sosyal bilimler için veri analizi el kitabı* [Handbook of data analysis for social sciences] (21st ed.). Pegem Akademi.
- Capobianco, B. M., Diefes-Dux, H. A., Mena, I., & Weller, J. (2011). "What is an engineer? Implications of elementary school student conceptions for engineering education." *Journal of Engineering Education*, 100(2): 304-328.
- Christensen, R., & Knezek, G. (2017). Relationship of middle school student STEM interest to career intent. *Journal of Education in Science, Environment and Health (JESEH)*, 3(1), 1-13. <https://doi.org/10.21891/jeseh.45721>
- Ciftci, A., Topcu, M. S., & Erdogan, I. (2020). Gender gap and career choices in STEM education: Turkey sample. *International Journal of Progressive Education*, 16(3), 53–66. <https://doi.org/10.29329/ijpe.2020.248.4>
- Crisp, G., Nora, A., & Taggart, A. (2009). Student characteristics, pre-college, college, and environmental factors as predictors of majoring in and earning a STEM degree: An analysis of students attending a hispanic serving institution. *American Educational Research Journal*, 46(4), 924–942. <https://doi.org/10.3102/0002831209349460>
- Cohen, J. (1992). A power primer. *Psychological Bulletin*, 112(1), 155–159.
- Faber, M., Unfried, A., Corn, J., & Townsend, L. W. (2013). Student attitudes toward STEM: The development of upper elementary school and middle/high school student surveys. *120th ASEE Annual Conference & Exposition*. <https://peer.asee.org/student-attitudes-toward-stem-the-development-of-upper-elementary-school-and-middle-high-school-student-surveys.pdf>
- Fan, C. (2013). Rural-urban migration and gender division of labor in transitional China. *International Journal of Urban and Regional Research*, 27(1), 24-47.
- Gonzalez, M., & Freyer, C. (2014). A collaborative initiative: STEM and universally designed curriculum for at-risk preschoolers. *National Teacher Education Journal*, 7(3), 21–29.

- Guzey, S. S., Caskurlu, S., & Kozan, K. (2020). Integrated STEM pedagogies and student learning. In C. C. Johnson, M. J. Mohr-Schroeder, T. J. Moore & L. D. English (Eds.), *Handbook of research on STEM education* (pp. 65-75). Routledge. <https://doi.org/10.4324/9780429021381>
- Hair, J. F., Blacks, W. C., Babin, B. J., & Anderson, R. E. (2019). *Multivariate data analysis* (8th ed.). Cengage Learning.
- Karakaya, F. ve Avgin, S. S. (2016). Effect of demographic features to middle school students' attitude towards FeTeMM (STEM). *Journal of Human Sciences*, 13(3), 4188-4198.
- Karakaya, F., Avgin, S. S., & Yılmaz, M. (2018). Middle school students' interest in science-technology, engineering and mathematics (STEM) professions. *Ihlara Journal of Educational Research*, 3(1), 36-53.
- Ketenci, T., Leroux, A., & Renken, M. (2020). Beyond student factors: A study of the impact on STEM career attainment. *Journal for STEM Education Research*, 3(3), 368-386. <https://doi.org/10.1007/s41979-020-00037-9>
- Knight, M., & Cunningham, C. (2004). *Draw an engineer test (DAET): Development of a tool to investigate students' ideas about engineers and engineering*. Paper presented at the ASEE Annual Conference and Exposition, 19 June, Utah.
- Koyunlu Ünlü, Z., & Dökme, İ. (2020). Multivariate assessment of middle school students' interest in STEM career: a profile from Turkey. *Research in Science Education*, 50(3), 1217-1231. <https://doi.org/10.1007/s11165-018-9729-4>
- Lavonen, J., Gedrovics, J., Byman, R., Meisalo, V., Juuti, K., & Uitto, A. (2008). Students' motivational orientations and career choice in science and technology: A comparative investigation in Finland and Latvia. *Journal of Baltic Science Education*, 7(2), 86-102.
- Legewie, J., & DiPrete, T. (2014). The high school environment and the gender gap in science and engineering. *Sociology of Education*, 87(4), 259-280.
- Liu, M., Horton, L., Olmanson, J., & Toprac, P. (2011). A study of learning and motivation in a new media enriched environment for middle school science. *Educational Technology Research and Development*, 59(2), 249-265.
- Murphy, S., MacDonald, A., Danaia, L., & Wang, C. (2018). An analysis of Australian STEM education strategies. *Policy Futures in Education*, 17(2), 122-139.
- National Research Council. (2011). *Successful STEM education: A workshop summary*. National Academies Press.
- National Science Foundation. (2003). *New formulas for America's workforce: Girls in science and engineering*. <https://www.nsf.gov/pubs/2003/nsf03207/nsf03207.pdf>.
- Olivarez, N. (2012). *The Impact of a STEM program on academic achievement of eighth grade students in a south texas middle school*. (Unpublished doctoral thesis). Texas A & M University: Texas. <https://www.proquest.com>
- Özcan,, H., & Koca, E. (2019). The Impact of teaching the subject "pressure" with STEM approach on the academic achievements of the secondary school 7th grade students and their attitudes towards STEM. *Education and Science*, 44(198), 201-227.
- Özyurt, M., Kuşdemir-Kayıran, B., & Başaran, M. (2018). Analysis of primary school students' attitudes towards stem in terms of various variables. *Turkish Studies*, 13(4), 65-82. <http://dx.doi.org/10.7827/TurkishStudies.12700>
- Partnership for 21st Century Skills (P21). (2006). *Framework for 21st century learning*. <https://www.ims.gov/assets/1/AssetManager/Bishop%20Pre-Con%202.pdf>
- Patton, M. (2002). *Qualitative evaluation and research methods*. Sage.
- Reinking, A., & Martin, B. (2018). The gender gap in STEM fields: Theories, movements, and ideas to engage girls in STEM. *Journal of New Approaches in Educational Research*, 7(2), 148-153.
- Sarı, U., Alıcı, M., & Şen, Ö. F. (2018). The effect of STEM instruction on attitude, career perception and career interest in a problem-based learning environment and student opinions. *Electronic Journal of Science Education*, 22(1), 1-21.
- Sivrikaya, Ö. S. (2019). Research of high school students' attitudes of STEM. *International Journal of Society Researches*, 11(18), 914-934. <https://doi.org/10.26466/opus.547459>

- Smith, E., & White, P. (2019). Where do all the STEM graduates go? Higher education, the labor market and career trajectories in the UK. *Journal of Science Education and Technology*, 28, 26–40. <https://doi.org/10.1007/s10956-018-9741-5>
- Stohlmann, M., Moore, T. J., & Roehrig, G. H. (2012). Considerations for teaching integrated STEM education. *Journal of Pre-College Engineering Education Research*, 2(1), 28–34. https://doi.org/10.5703/12882_84314_653.
- TUSIAD. (2017). 2023'edođru Türkiye'de STEM gereksinimi [STEM requirements in Turkey towards to 2023]. <https://www.pwc.com.tr/tr/gundem/dijital/2023e-dogru-turkiyede-stem-gereksinimi.html>
- U.S. Bureau of Labor Statistics. (2021). *Employment in STEM occupations*. <https://www.bls.gov/emp/tables/stem-employment.htm>
- Walton, J. B., & Johnson, C. C. (2015). Examining the leaky STEM talent pipeline: Need for further research. Editorial. *School Science and Mathematics*, 115(8), 379–380. <https://doi.org/10.1111/ssm.12148>
- Wiebe, E., Unfried, A., & Faber, M. (2018). The relationship of STEM attitudes and career interest. *EURASIA Journal of Mathematics, Science and Technology Education*, 14(10), 1–17. <https://doi.org/10.29333/ejmste/92286>
- Yerdelen, S., Kahraman, N., & Taş, Y. (2016). Low socioeconomic status students' STEM career interest in relation to gender, grade level, and STEM attitude. *Journal of Turkish Science Education*, 13 (Special Issue), 59-74.
- Yıldırım, B. (2021). Preschool STEM activities: preschool teachers' preparation and views. *Early Childhood Education Journal*, 49, 149–162. <https://doi.org/10.1007/s10643-020-01056-2>
- Yıldırım, B., & Selvi, M. (2017). An experimental research on effects of STEM applications and mastery learning. *Journal of Theory and Practice in Education*, 13(2), 183-210.
- Yıldırım, B., & Türk, C. (2018). The effect of STEM applications on girls' STEM attitude and engineering perception. *Adıyaman Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, 10(30), 842-884.