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The Determination Of High School Students' Attitudes Towards Stem

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The study aims to determine the attitudes of high school students toward STEM. During the development of the survey, a pilot study and the main study was conducted. The pilot study was conducted primarily for the collection and statistical analysis of the research data. Exploratory and Confirmatory Factor Analysis was carried out for the pilot survey. The statistical results show that the pilot study was reliable and acceptable. The main study was conducted for the comparison and discussion of the research data. The sample of the study comprised 2118 high school students in 12 high schools during the academic year 2018-2019 in Izmir, Turkey. The results showed that the mean score of students' attitudes on STEM decreased from 9th grade to 12th grade in both the metropolitan and suburban areas of the city. Results for gender differences show that the mean score of male high school students' attitude towards STEM was higher than the mean score of female high school students in both metropolitan and suburban areas.

KEYWORDS: Attitude, High School, STEM Education

Introduction

In the age of information and technology, multidisciplinary research has become important. STEM (science, technology, engineering, and mathematics), one of the multidisciplinary education approaches, was founded in the 1990s (Sanders, 2009). Brown, Brown, Reardon, Merrill (2011, p.6) defined STEM education as "a standards-based, meta-discipline residing at the school level where all teachers, especially science, technology, engineering, and mathematics (STEM) teachers, teach an integrated approach to teaching and learning, where discipline-specific content is not divided, but addressed and

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treated as one dynamic, fluid study".

Bybee (2011, p.6) states that STEM education focuses on eight factors. The factors are "asking questions and defining problems, developing and using models, planning and carrying out investigations, analysing and interpreting data, using mathematics and computational thinking, constructing explanations, designing solutions, engaging in argument from evidence, obtaining, evaluating, and communicating information". The factors identified can be performed in the disciplines of science, technology, engineering, and mathematics using the following activities. Initiating a problem, conducting the problem, and presenting the problem can be applied in science activities. Using technology based on software can be performed in technology activities. Defining a problem to be solved, creating a solution to the problem, and applying the solution can be performed in engineering activities. Collecting, processing, and representing data can be performed in mathematical activities (So, Zhan, Chow, & Leung, 2018). If teachers who have taken the STEM training use the specified activities in their own classes, it can make a significant contribution to the success of STEM activities and attitude of students.

Review Of Literature

STEM education has three purposes. The first purpose is to increase the number of students to continue in STEM fields. The second purpose is to broaden participation in the STEM workforce. The last purpose is to educate individuals with STEM literacy skills. When the established purposes are taken into consideration, STEM education has rapidly gained importance worldwide (Aslan-Tutak, Akaygun, & Tezsezen, 2017; Christensen, Knezek, & Tyler-Wood, 2015; Kennedy & Odell, 2014; Unfried, Faber, Stanhope, & Wiebe, 2015).

STEM education helps students improve 21st century skills such as media and technology literacy, creativity, information resource management, problem solving skills, numeracy skills, communication and collaboration skills, teamwork skills, self-management skills, social skills, etc. (Becker & Park, 2011). STEM education contributes significantly to the importance of science and mathematics, the emphasis on technology, and the recognition of technology at all grade levels (Maltese & Tai, 2011; Sadler, Sonnert, Hazari, & Tai, 2012; Sanders, 2009; Unfried et al., 2015). If STEM education is applied to all grade levels, some changes (teaching methods and strategies, assessment and evaluation techniques, pedagogical approaches, teacher training programs, curricula, etc.) could be made in the current education system (Blackley & Howell, 2015; Kennedy & Odell, 2014; Merrill, 2001; Sanders, 2009).

Peter, Lynch, Behrend, and Means (2014) pointed out some critical components (design, implementation, and outcomes) to improve student achievement and support STEM education with innovation. Teachers have an important role in STEM education. STEM education can be successful with motivated and highly qualified teachers (Mcdonald, 2016). In addition to these components, the teacher component can be added. When the components for STEM education are brought together, teachers trained in STEM education can positively contribute to the success, attitude, and motivation of students in their classes. Becker & Park (2011, p. 24) pointed out that "STEM teachers' implementation of the integrative approaches highly depends on their individual characteristics when accepting a new instructional method, their perceptions towards the integrative approach, school context, delivery methods, and so on".

Many studies (Lovelace & Brickman, 2013; Osborne, Simon, & Collins, 2003; Tabata & Johnsrud, 2008; Tapia & Marsh, 2004; Tseng, Chang, Lou, & Chen, 2013; Tyler-Wood, Knezek, & Christensen, 2010; Usher, 2009) showed that STEM education positively influences students' attitudes. Many studies (Capraro et al., 2016; Chien & Chu, 2018; Guzey, Ring-Whalen, Harwell, & Peralta, 2019; Han, Capraro, & Capraro, 2015; Kizilay, Yamak, & Kavak, 2019) also showed that STEM education improves students' academic achievement, motivation, self-confidence, creativity, etc., regardless of grade level.

In examining the relevant literature, it has been found that only a limited number of studies have been conducted on attitudes towards STEM domains. Many researchers (Guzey, Harwell, & Moore, 2014; Kier, Blanchard, Osborne, & Albert, 2014; Landicho, 2020) have developed surveys on attitudes towards STEM based on the demographics of their own country.

Some researchers (Ozcan & Koca, 2019; Unlu, Dokme, & Unlu, 2016; Yilmaz, Koyunkaya, Guler, & Guzey, 2017) in our country adapted the developed STEM attitude surveys to our students. The aim of studies in this field should be to develop attitude survey considering the social and cultural structure of the country where students live.

Stem Educational Approach In Turkey

In our country, several researchers (Kizilay et al., 2019; Unlu et al., 2016; Yilmaz et al., 2017) have conducted research studies on STEM education in different fields and subjects as in other countries (United States, United Kingdom, India, etc.), but the number of studies is not sufficient.

There are two important factors that prevent the implementation of STEM education. The first factor is the availability of a qualified STEM teacher. Many physics, chemistry, biology and mathematics teachers generally apply traditional education approaches instead of STEM education approach in their own classes. They have no experience in any form of cooperative learning, problem-based learning, project-based learning, etc., to conduct STEM education.

The second factor is the current equipment of high schools to implement STEM education. If we evaluate the current conditions of high schools in terms of STEM education, we could say that the laboratory facilities are inadequate. The practical and intellectual activities of the students are not supported by the school authorities because the number of teachers trained for STEM education activities is very low. The factors identified may have a negative impact on students' motivation, attitude, self-confidence and career choice towards STEM fields.

Objectives Of The Study

The main objective of the study is to determine the attitudes of high school students considering the demographic structure of Turkish students using the newly developed Science, Technology, Engineering, Mathematics - Attitude survey (STEM -A) instead of using the previously developed survey. It is expected that the developed STEM -A survey will fill the gap in the literature for developing countries in the present study. In addition, the developed survey was used to investigate the following research questions in the study:

1. Is there a meaningful difference between the STEM -A survey of students taught in metropolitan and suburban areas by grade level?

2. Do the STEM -A scores of female students taught in metropolitan and suburban areas differ by grade level?

3. Do the STEM -A scores of male students taught in metropolitan and suburban areas differ by grade level?

Research Methodology

The present study consisted of two sections. The first section was the pilot survey study. The principles of Devellis (2012) were used in the development processes of the pilot survey. The researcher first conducted a literature review (Faber et al., 2013; Guzey et al., 2014; Kier et al., 2014; Usher, 2009). Then, the researcher received written opinions of 30 volunteer students on STEM education. The researcher generated survey items in light of the data obtained. The expert opinions were used for the survey items. Finally, statistical analysis was conducted for the reliability and validity of the pilot survey. The pilot survey consisted of 33 items on the 5-point Likert scale from "strongly agree-5″ to ″strongly disagree-1″. The second section was the main survey. The data obtained from the developed survey was discussed and compared by gender, area, and grade levels of high school students.

Sample Of The Study

Pilot survey data were collected from 1014 students in seven public high schools during the 2018-2019 academic year in the third largest city (Izmir) of Turkey. High schools in Turkey have classes from 9th to 12th grade. The high schools which were a part of the sample have never implemented STEM education. The pilot study was conducted in two areas of Izmir in order to generalise the results of the research. The first area was the metropolitan area that covered two districts i.e., Bayrakli and Bornova. The second area was a suburban are namely, Torbali which was located near the city centre. All students voluntarily participated in the research. Students were asked to complete the survey anonymously. The student surveys were randomly coded.

Table 1 shows the distribution of high school students by grade level. High school students in 11th and 12th grade did not participate in the pilot survey. This group of students was not included in the pilot survey due to their preparation for the university entrance exam.

Table 1

Characteristics of the Sample for STEM-A Survey.

	Female	**%**	**Male**	**%**	**Total**	**%**
9th Grade	310	58.2	223	41.8	533	58.97
10th Grade	288	59.9	198	40.1	481	41.03

Students were given approximately ten minutes to complete the pilot survey in their own class time. Before the pilot survey was handed out, students were given a brief information about the pilot survey.

Data Analysis

Statistical analysis of the pilot survey was examined using the Exploratory Factor analysis (EFA) and Confirmatory Factor Analysis (CFA). The EFA was conducted using IBM SPSS Statistics 25 and the CFA was conducted using IBM SPSS AMOS 25 graphing programme.

Exploratory Factor Analysis

The statistical analysis data on the pilot survey were reported as follows: Bartlett's test was found to be significant (p .001), Kaiser-Meyer-Olkin (KMO) value was calculated as 0.91, total variance was measured as 61.94% and Cronbach's alpha value was calculated as 0.85. The data obtained showed that the factor analysis of the pilot survey was appropriate (Hair, Black, Babin, & Anderson, 2014; Kline, 2011; Tabachnick & Fidell, 2012). Figure 1 shows the relationship between the items and eigen values of the pilot survey.

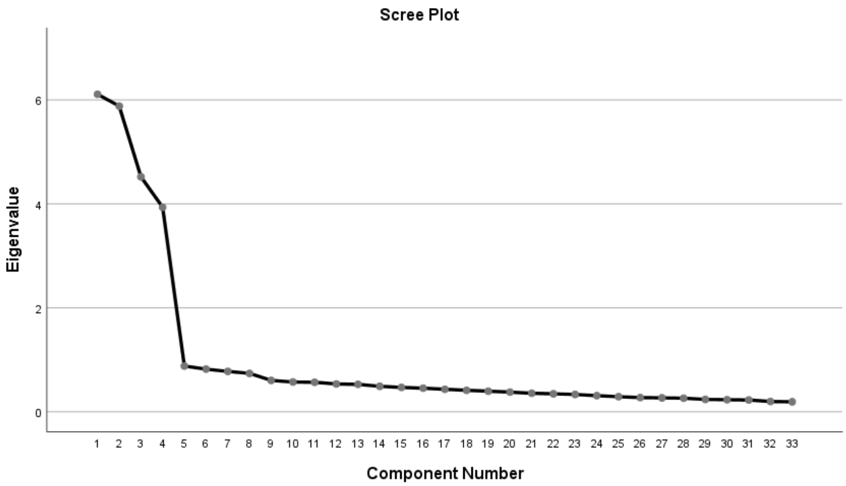

Figure 1. Scree Plot for STEM-A Survey

Table 2 shows the items and factor loadings of the subfactors based on the exploratory factor analysis. When evaluating the studies (Hair et al., 2014; Tabachnick & Fidell, 2012), it was found that the obtained scores from the exploratory factor analysis were acceptable.

Table 2

Items and Factor Loadings of STEM-A Survey.

Item Numbers		Items	S	T	E	M
1	SC3	I like science classes.	.83			
2	SC5	I like to solve problems related to science class	.82			

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Table 2 continued

Item Numbers			Items	S	T	E	M
	3	SC14	I like to attend science classes	.80			
S	4	SC1	I like to make a career in science field	.77			
	5	SC15	I can do an advanced study in science field	.76			
	6	SC13	I like to participate in project studies on science	.73			
	7	SC2	I can take high scores in science classes	.71			
	8	SC4	I work hard for science classes	.70			
	9	TC13	I like to attend technology classes		.87		
	10	TC2	I like technology classes		.84		
T	11	TC14	I like to participate in project studies on technology field.		.82		
	12	TC12	I can do an advanced study in technology field		.81		
	13	TC1	I like to make a career in technology field		.80		
	14	TC4	I work hard for technology classes		.74		
	15	EG7	I like to participate in projects on engineering field			.86	
	16	EG8	I like to attend engineering classes			.85	
	17	EG9	I try to follow new developments in engineering field			.82	
	18	EG10	I can do an advanced study in engineering field			.80	

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Table 2 continued

Item Numbers			**Items**	S	T	E	M
E	19	EG6	I like to learn operation principles of electronic devices			.79	
	20	EG17	I like reading scientific books and journals on engineering field			.74	
	21	EG18	I like to watch documentary about engineering field			.74	
	22	EG5	I like to repair electronic devices			.74	
	23	EG1	I like to make a career in engineering field			.73	
	24	EG4	I can develop new and creative ideas in engineering field			.68	
	25	MT3	I like mathematics classes				.87
	26	MT5	I like to solve mathematics problems				.84
	27	MT8	I like to attend mathematics classes				.84
	28	MT7	I like to participate in projects on mathematics field				.83
M	29	MT2	I can take high scores in mathematic classes				.82
	30	MT9	I can do an advanced study in mathematics field				.80
	31	MT1	I like to make a career in mathematics field				.77
	32	MT4	I work hard for mathematics classes				.74
	33	MT6	I can do my mathematics homework				.66

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Table 2 continued

Item Numbers	Items	S	T	E	M
Cronbach's Alpha value of the sub-factor		.90	.90	.93	.93
Eigenvalue		4.52	3.93	6.11	5.88
Percentage of explained variance		13.69	11.92	18.51	17.82

Note: S: Science; T: Technology; E: Engineering; M: Mathematics

Confirmatory Factor Analysis

CFA was performed to calculate the fit indexes. The CFA values are expected results between acceptable fit and good fit. Table 3 illustrates the values of the CFA.

Table 3

The Results of CFA.

Fit Index Type	Measurement	Acceptable Fit	Good Fit
Minimum Discrepancy Per Degree of Freedom (CMIN/DF)	3.12	$x^2/sd \leq 5$	$x^2/sd \leq 3$
Normed Fit Index (NFI)	.92	$.90 \leq NFI$	$.95 \leq NFI$
Non-Normed Fit Index (NNFI)	.94	$.90 \leq NNFI$	$.95 \leq NNFI$
Incremental Fit Index (IFI)	.95	$.90 \leq IFI$	$.95 \leq IFI$
Comparative of Fit Index (CFI)	.95	$.95 \leq CFI$	$.97 \leq CFI$
Root Mean Square Error Approximation (RMSEA)	.04	$RMSEA \leq .08$	$RMSEA \leq .05$
Goodness of Fit Index (GFI)	.91	$.85 \leq GFI$	$.90 \leq GFI$
Adjusted Goodness of Fit Index (AGFI)	.89	$.85 \leq AGFI$	$.90 \leq AGFI$
Adjusted Goodness of Fit Index (RMR)	.04	$0 < RMR \leq .08$	$0 < RMR \leq .05$

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Table 3 continued

Fit Index Type	Measurement	Acceptable Fit	Good Fit
Standardized Root Mean Square Residual (SRMR)	.02	$0 < SRMR \leq$ .08	$0 < SRMR \leq$ .05

The obtained results of CFA according to the investigated reference studies (Byrne, 2013; Karagoz, 2016) showed that the calculated fit indexes were between acceptance fit and good fit. Figure 2 shows the standardized values of the pilot survey obtained from the CFA. The statistical analysis results based on EFA and CFA showed that the pilot survey was reliable.

Results Of The Study

The main study was conducted to evaluate the results of the developed survey. The study was conducted in different high schools except for the high schools visited for the pilot study. The developed survey data was collected from 1104 students in five different high schools. 721 students live in the metropolitan area and the others live in the suburban area. 639 of 1104 high school students were female and the other students were male. Table 4 shows the distributions by area, gender, and grade level of students. Table 5 and Table 6 present the descriptive statistics of STEM -A survey.

Table 4

The Characteristics of the Sample for the Developed STEM-A Survey.

	Female				Male				T	
Grade	**M**	**%**	**S**	**%**	**M**	**%**	**S**	**%**	**M-S**	**%**
9th	118	27.96	43	19.82	79	26.42	33	19.88	273	24.73
10th	111	26.30	53	24.42	80	26.76	34	20.48	278	25.18
11 th	79	18.73	74	34.10	62	20.74	60	36.14	275	24.91
12 th	114	27.01	47	21.66	78	26.08	39	23.50	278	25.18

Note: M: Metropolitan; S: Suburban; T: Total

According to the first research question, there was no significant difference between students taught in 10th grade (t(276)= 0.18 p .05), 11th grade (t(273)= 1.73 p .05), and 12th grade (t(276)= 1.60 p .05), with the exception of 9th grade (t(271)= 5.05 p .05). The significant difference that occurred was at the 9th grade level in suburban area. When comparing the subfactors of the

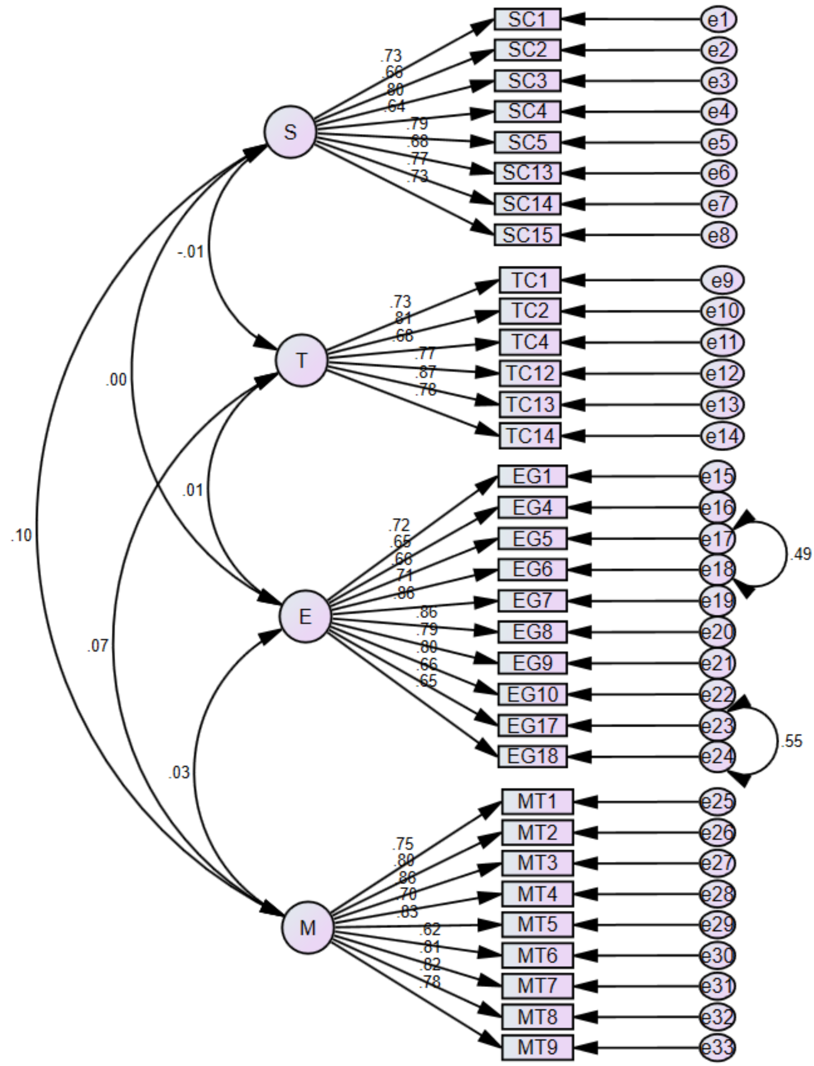

Figure 2. Path Diagram for STEM-A Survey

Table 5

Grade Wise Mean Scores for Male and Female Students of STEM-A for Metropolitan Area.

	9^{th} G			10^{th} G			11^{th} G			12^{th} G		
	F	**M**	**T**	**F**	**M**	**T**	**F**	**M**	**T**	**F**	**M**	**T**
S	25.41	22.51	24.24	24.31	25.69	24.88	25.34	25.15	25.26	20.89	21.88	21.30
T	17.01	21.04	18.62	16.16	21.46	18.38	16.54	21.10	18.55	15.74	20.95	17.85
E	29.04	32.53	30.44	26.77	36.54	30.86	28.00	34.00	30.64	25.61	35.62	29.68
M	29.14	25.97	27.87	29.30	29.24	29.27	31.80	29.92	30.97	26.49	29.19	27.59
STEM	100.59	102.05	101.18	96.54	112.93	103.40	101.68	110.16	105.41	88.74	107.64	96.42

Note: G: Grade F: Female . M: Male

Table 6

Grade Wise Mean Scores for Male and Female Students of STEM-A for Suburban Area.

	9^{th} G			10^{th} G			11^{th} G			12^{th} G		
	F	M	T	F	M	T	F	M	T	F	M	T
S	26.93	27.82	27.32	23.17	24.41	23.66	27.12	26.32	26.76	22.85	22.90	22.87
T	17.40	24.88	20.64	15.23	22.47	18.06	16.78	21.17	18.75	16.96	21.67	19.03
E	33.42	40.70	36.58	28.30	37.59	31.93	30.38	36.47	33.10	27.98	37.62	32.35
M	31.98	32.48	32.20	28.43	30.03	29.06	32.26	32.37	32.31	30.55	27.36	29.10
STEM	109.72	125.88	116.74	95.13	114.50	102.70	106.54	116.32	110.92	98.34	109.54	103.42

Note: G: Grade F: Female . M: Male

STEM -A survey of students in the areas, the 9th grade students who were taught in the suburban area might have had a greater interest in STEM fields compared to the students in the metropolitan area. They might have followed the developments and innovations in the fields of technology and engineering more closely. In addition, students taught in the suburban area might be more focused on STEM instruction than on social and cultural activities. Students in the 10th grade began to identify their interests (e.g., science, social, sports, arts, etc.). Figure 3 shows that the STEM -A mean of students in 10th grade. Many students in 11th and 12th grade preferred to prepare for university entrance exams rather than explore STEM fields. Therefore, students might not have shown sufficient interest in STEM lectures due to exam stress.

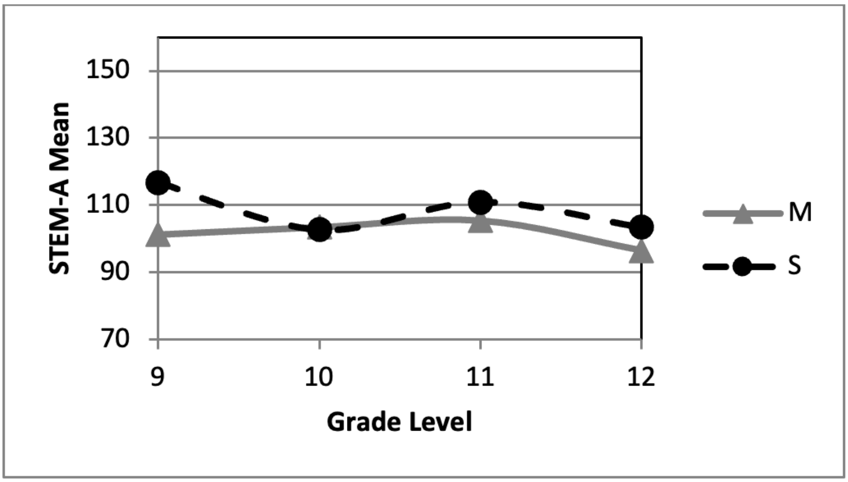

Figure 3. The Relationship between STEM-A Mean and Grade Level according to the Areas.

The decrease in the graph shows that the STEM attitudes of high school students in metropolitan and suburban areas changed during the transition from 9th to 12th grade. The reasons for the decrease in STEM attitudes of students can be explained under three points (students, teachers, and schools): i) Many high school students in the areas may not have been interested in STEM fields and classes. Students may have a desire to pursue their careers in other fields (e.g., political science, fine arts, social science, physical education, etc.) ii) Many teachers may not have received STEM training. They may have used traditional educational methods instead of the STEM educational approach. Science teachers may have conducted lessons in the classroom rather than in the laboratory, so many students have less interest and curiosity in STEM fields and iii) The necessary and sufficient physical conditions (e.g., budget, laboratory equipment, classroom, computers, Internet, etc.) of high schools may not be suitable for STEM education.

Figure 4 shows STEM - A mean of female and male students educated in metropolitan and suburban areas, according to grade levels.(F-M:Female-Metropolitan; M-M: Male-Metropolitan; F-S: Female-Suburban; M-S: Male-Suburban)

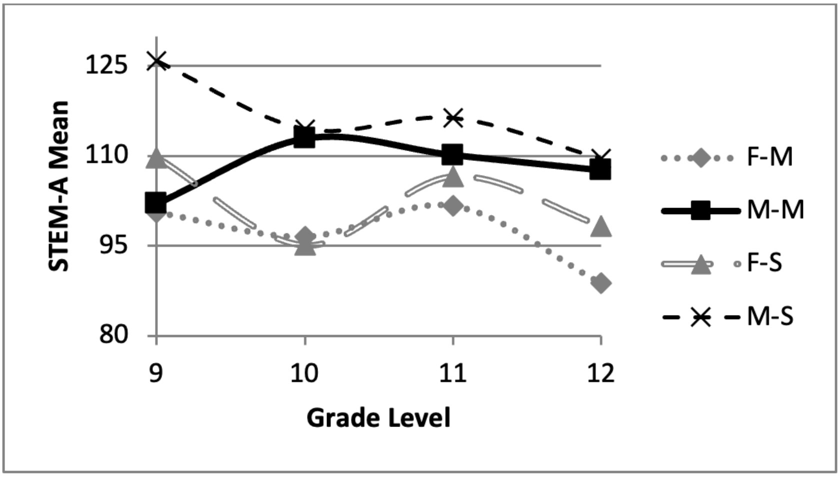

Figure 4. The Relationship between STEM-A Mean and Grade Level according to Gender.

According to the second and third research questions, the STEM -A mean score of female students taught in metropolitan and suburban areas is generally from 9th to 12th grade. It can be said that female students in suburban area showed more interest in STEM fields than female students in metropolitan area. STEM-A mean score of male students in metropolitan increased slightly while STEM -A mean score of males in suburban increased from 9th to 12th grade. As can be seen from Figure 4, male students in metropolitan and suburban were generally more interested in STEM fields than female students.

Figure 5 shows the mean score of science attitude (S-A) of female and male students in metropolitan and suburban areas. The S-A mean of male students in the metropolitan area did not change significantly, while the S-A mean of female and male students in the suburban area decreased by almost 10 percent from 9th to 12th grade. The S-A mean for female students in metropolitan area dropped by the same rate. Students' interest in science education did not change significantly between grade levels. Many students' mean science attitudes were influenced primarily by two factors: i) they may have perceived

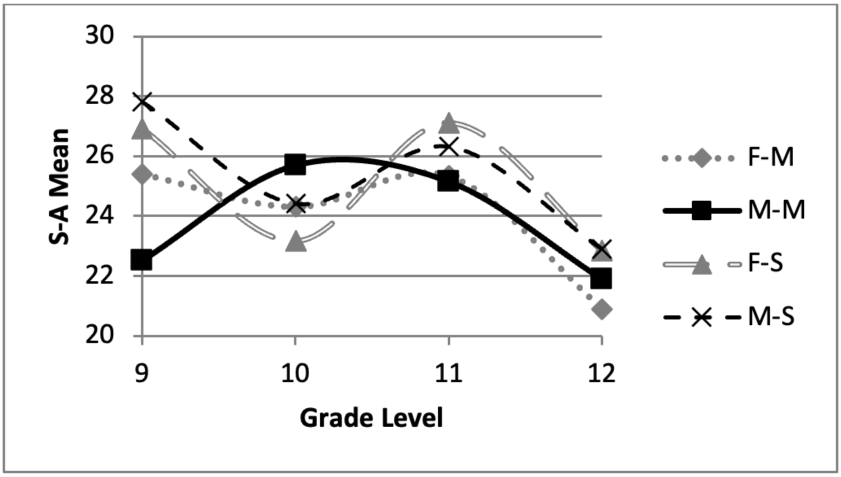

Figure 5. The Relationship between S -A Mean and Grade Level

themselves to be inadequate for science instructions and ii) they may have shown no interest in science instructions.

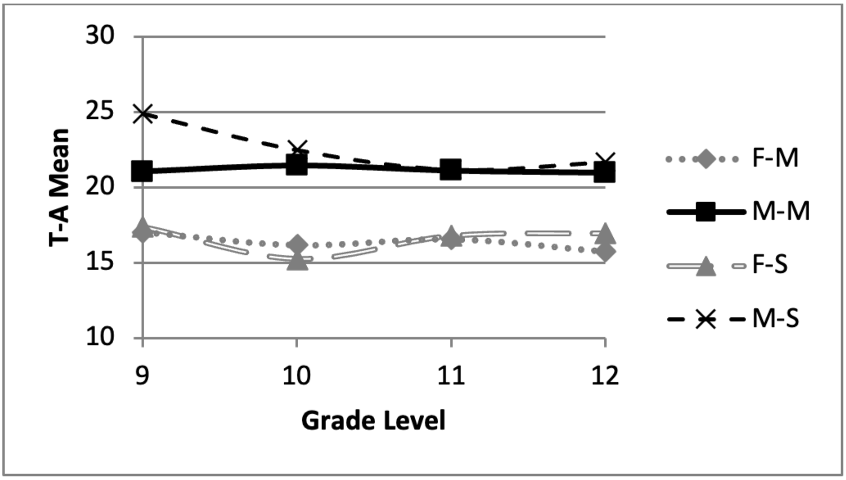

Figure 6. The Relationship between T-A Mean and Grade Level

Figure 6 shows the mean of technology attitude (T-A) of female and male students in metropolitan and suburban areas. The T-A mean of female students has slightly decreased from 9th grade to 12th grade in metropolitan and suburban areas. The S-A mean of male students in suburban area decreased significantly by 10 percent. The T-A mean of male students in the metropolitan area changed slightly. As shown in Figure 6, many students were not interested in technology, except for the male students in the metropolitan area, they directed their interests and curiosity to other areas, they may not have participated in technology design and computer classes in their schools.

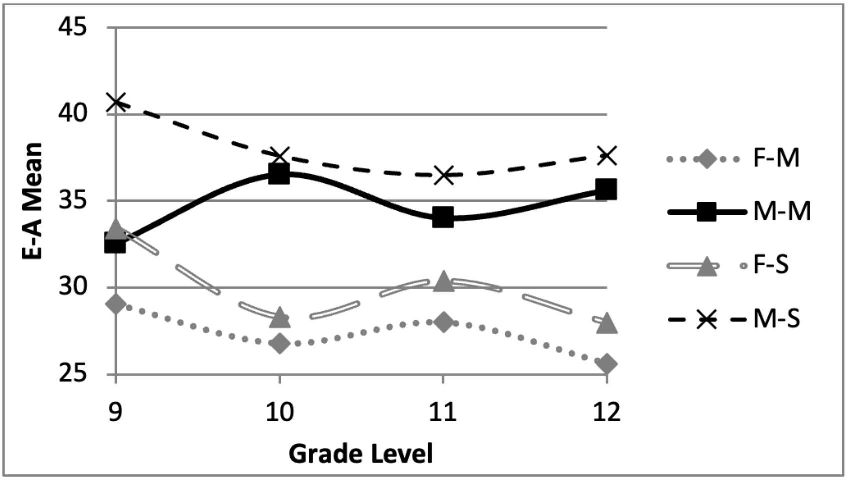

Figure 7. The Relationship between E-A Mean and Grade Level

Figure 7 shows the mean of Engineering Attitude (E-A) of female and male students in metropolitan and suburban areas. The E-A mean of the male students in the metropolitan area increased while the E-A mean of the other students decreased from 9th to 12th grade. The E-A mean of the female students in the suburban area decreased negatively by almost 10 percent. The E-A mean score of male students in the areas was higher than the E-A mean score of female students. It can be said that the mean score of technical attitudes of male students in metropolitan area was higher than the mean score of technical attitudes of female students, as well as the mean score of technical attitudes.

Figure 8 shows the mean of mathematics attitude (M-A) of female and male students in metropolitan and suburban areas. The M-A mean scores of all students except male students in metropolitan area decreased. The M-A mean score of students showed fluctuations from 9th to 12th grade, as did the mean score of science attitude. The results of the research indicated that students generally show resistance to understanding and learning science and mathematics classes.

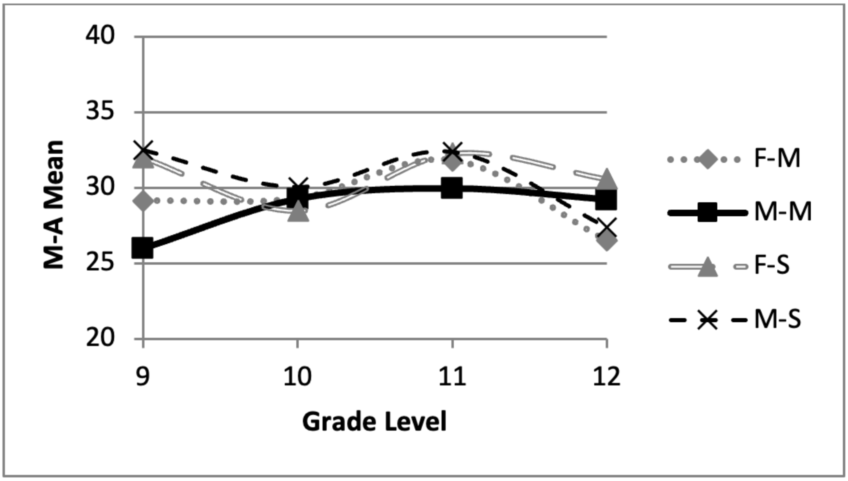

Figure 8. The Relationship between M-A Mean and Grade Level

Conclusions

The present study differs from the previously developed STEM studies (Cevik, 2017; Faber et al., 2013; Guzey et al., 2014; Kier et al., 2014; Luo, Wei, Ritzhaupt, Huggins-Manley, & Gardner-McCune, 2019; Tyler-Wood et al., 2010; Unfried et al., 2015; Yilmaz et al., 2017). In this study, the survey development processes were investigated and analysed, the collected data were discussed and compared by gender, grade level, and areas using the developed survey.

The development processes of the survey as a so-called pilot study were examined using the statistical analysis. The results of statistical analysis based on EFA and CFA showed that the survey was reliable and acceptable to identify the STEM -A of high school students. The developed survey was not an adaptation of a survey as in other studies (Ozcan & Koca, 2019; Unlu et al., 2016; Yilmaz et al., 2017). The demographic characteristics of Turkish students were considered in the developed survey.

According to the results of the survey, the mean scores of male students STEM -A were higher than those of female students STEM -A. Many studies (Ciftci, Topcu, & Erdogan, 2020; Ikkatai et al., 2020; Makarova, Aeschlimann, & Herzog, 2019; Sadler et al., 2012) indicated that female and male students have different attitudes toward science, technology, engineering, and mathematics and supported the result of the research. The studies showed that male students have more interest in STEM fields than female students. Chachashvilli, Milner-Bolotin, & Lissitsa (2016) and Wiebe, Unfried, and Faber

(2018) showed a strong correlation between students' attitudes and interest in STEM careers.

The mean score of students' science and mathematics attitudes generally decreased from 9th to 12th grade. The mean score of male students' attitudes towards technology and engineering was higher than the mean score of female students' attitudes. But male students living in metropolitan area showed the highest interest in technology and engineering by suburban area. Some research findings (Christensen et al., 2015; Halim, Rahman, Wahab, & Mohtar, 2018; Potvin & Hasni, 2014; Sadler et al., 2012) confirmed the findings of the study. Kelley and Knowles (2016) found that cultural, social, political, economic, and environmental factors influence STEM education. The findings revealed that the social environment of high school students influenced their attitude towards STEM. Consequently, the research findings indicated that students' social environment and gender mainly influence students' attitude towards STEM fields, their interests and career choices.

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