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DETERMINING LOWER-SECONDARY STUDENTS' STEM MOTIVATION: A PROFILE FROM TURKEY

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Abstract. *The ongoing motivation of students toward the fields of science, technology, engineering, and mathematics (STEM) is a process related to their orientation toward those fields and their active participation in related activities. This study aimed to examine the ongoing STEM motivations of lower-secondary school students in a sample from Turkey according to demographic variables. In this study, in which 1926 students from 12 provinces participated, the students' STEM motivations were compared according to the variables of gender, place of residence, grade level, school type, "mothers' and fathers' education level, and family income level. T-tests and ANOVA testing were used in the analysis process via SPSS package program. As a result, male students' STEM motivations were found to be at higher levels than those of female students. The STEM motivations of gifted students were found to be higher than those of students studying in religiously oriented education institutions. The results also revealed that STEM motivation is directly proportional to the education level of the parents. The results obtained in this study, reflecting the general profile of STEM motivation among students in Turkey, may guide education policy makers, program developers, teachers, prospective teachers, and researchers on STEM education.*

Keywords: *lower-secondary school students, quantitative research, STEM, STEM motivation*

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Introduction

Science, technology, engineering, and mathematics (STEM) are disciplines that are critical to the economic development of any country (NRC, 2011). STEM education aims to encourage students to solve real-world problems, collaborate, integrate these four disciplines (Mutambara & Bayaga, 2021), and pursue STEM careers (Ritz & Fan, 2015; Rosenzweig & Wigfield, 2016). Demands and expectations for STEM education are being expressed in Turkey as well as in reports prepared in the United States and Europe. Examples include the "National Science and Technology Policies 2003-2023 Strategy Document" published by the Scientific and Technological Research Council of Turkey (TÜBİTAK) and the "Demand and Expectations Research Report for Labor Force Educated in Science, Technology, Engineering, Mathematics" published in 2014. These reports highlight the need to make changes at all levels of the educational system in order to train R&D personnel specialized in specific fields of science and technology, to prepare people who have received science and mathematics education to work successfully with future technologies and the fields of science that support those technologies, and to educate people who can work in STEM fields with innovative qualities and meet the necessary demands of those fields. According to a report published by the Turkish Industry and Business Association (TUSIAD) (2017), approximately 3.5 million of the 34 million jobs in Turkey in 2023 will be in STEM fields. It is further predicted that the need for new STEM employees will approach 1 million in the period of 2016-2023 and there will be a deficit of approximately 31% on the basis of graduates meeting that need. According to purchasing power parity, Turkey will be the 12th largest economy in the world in 2030, while it is expected to be the 11th in 2050. Therefore, a properly trained workforce is needed in STEM fields (TUSIAD, 2017). Countries are updating their education policies to support orientation toward STEM fields. Taking into account the relevant published reports, the Ministry of National Education (MoNE) of Turkey updated the science curriculum in 2018 to begin implementing STEM education starting from the 5th grade. The current science curriculum aims to integrate students with mathematics, technology, and engineering and to deal with daily problems from an interdisciplinary perspective (MoNE, 2018). The orientation of students toward STEM fields must be supported by STEM-based curricula in primary and lower-secondary schools (Bybee, 2013). In this regard, an important prerequisite for STEM learning is students' motivation for

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STEM (Maltese et al., 2014; Rosenzweig & Wigfield, 2016). STEM motivation generally tends to decrease among students in lower-secondary school and high school (Potvin & Hasni, 2014), and one way to increase student engagement in STEM fields is to target their motivation (Rosenzweig & Wigfield, 2016). Determining students' STEM motivation and the effects of different variables on that motivation level can give important clues about how STEM is applied in lower-secondary schools. Therefore, this study aimed to contribute to the literature by providing a comprehensive understanding of the impact of STEM motivation according to certain demographic variables.

Conceptual Framework

"Motivation" refers to someone's desire to achieve a task or a goal. It determines success or failure in completing any complex task (Fadzli et al., 2020). Experts believe that if students are not motivated, they perform inadequately and are less likely to learn. In contrast, students who are motivated to learn are more likely to process the knowledge they have acquired (Biggs & Tang, 2011), pay attention to details, and make connections between ideas (Entwistle & McCune, 2013). Leon et al. (2015) concluded that when students feel that their schoolwork is purposeful and engaging, and that the classroom environment and teachers are responsive and supportive, they will be independently motivated to engage in self-regulated learning. Freeman, et al. (2015) stated that the roles of motivation and collaboration are very important in STEM learning and performance. In addition to these studies aiming to reveal the factors affecting motivation, Jaafar and Maat (2020) examined the relationship between STEM education and motivation within five six important categories: non-cognitive factors, pedagogy, gender, mathematics curriculum, and socioeconomic demographics. However, the studies conducted on STEM motivation to date were not conducted with large numbers of participants. For that reason, effects on STEM motivation were examined in the present research within the categories of STEM and gender, STEM and place of residence, STEM and grade level, STEM and school type, STEM and parental education levels, and STEM and family income level.

STEM and Gender

It is widely agreed that women are underrepresented in STEM-related careers and that gender equality has not been achieved in these fields (Craig et al., 2018; Ivie & Tesfaye, 2012; LeGrand, 2013; Smith, 2011), and female students are often less interested in STEM careers than male students (Unfried et al., 2014). Chavatzia (2017) stated that women make up only 35% of all students enrolled in STEM-related fields of study in higher education. The underrepresentation of women in STEM fields is a problem for society, organizations, employers, and individuals, threatening the power of global competitiveness. The underrepresentation of women in STEM fields also causes social inequality. For this reason, it is necessary to focus on this problem and to find a solution for it (Fox et al., 2011). In short, studies have revealed that gender is an important factor in attitudes toward STEM fields and interest in STEM careers. Women have been found to have lower interest in these fields, especially in the case of engineering and technology aspects of STEM applications, and women are less commonly employed in STEM environments (Murphy et al., 2007). Research conducted at the high school level has found that male students' attitudes toward STEM are more positive than those of female students (Unfried et al., 2014). At the level of higher education, Xu (2008) found that men are more likely to pursue work in STEM-related positions. Similarly, in the STEM Education Turkey Report, it is recommended that female students be particularly encouraged to pursue education and careers in STEM fields (Akgündüz et al., 2015). As women are underrepresented in many STEM fields, it is necessary to remove the barriers to girls' early STEM participation and to motivate more students to pursue STEM careers (Hill et al., 2010). Addressing STEM motivation in childhood is important because positive attitudes toward STEM decline between primary and lower-secondary school and gender differences in motivation emerge (Master & Meltzoff, 2020). Research shows that the gender disparities in STEM are largely due to fundamental differences in motivation rather than incompetence (O'Dea et al., 2018).

STEM and Place of Residence

When variations among students according to their long-term places of residence are examined, there is a significant difference in the interest levels of lower-secondary school students toward science, mathematics, technology, engineering, and STEM professions, with interest levels being higher among students who have lived in provincial or district centers for a long time (Karakaya et al., 2018). In the study conducted by Aydın et al. (2017) STEM attitude scores of students were compared according to the city the students lived in, and a significant difference was observed

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between smaller cities and metropolitan cities. Compared to larger cities, children in smaller cities are more likely to witness more examples from life in the natural environment outside of school relevant to the fields of science, mathematics, and engineering. In smaller cities, informal learning environments such as gardens or neighborhoods allow the construction of knowledge with the leadership of the students themselves, providing a student-centered learning environment based on inquiry, critical thinking, and problem solving (Ricks, 2006). However, the relationship between place of residence and STEM motivation has not been adequately studied.

STEM and Grade Level

In their study, Aydın et al. (2017) examined students' attitudes toward STEM and determined that the STEM attitude scores of students in the 4th, 5th, 6th, 7th, and 8th grades in their sample group revealed a significant difference in favor of the 4th and 5th grades. This reveals that students are more interested in science, mathematics, engineering, and technology at younger ages and their readiness for STEM applications is higher than that of older students. This finding also coincides with the results of studies conducted by Unfried et al. (2015), and Lamb et al. (2015). This result is further supported by the 2015 Trends in International Mathematics and Science Study (TIMSS) exam results. While Turkey ranked first among 4th grade students stating that they liked learning mathematics very much (79%), it ranked second among students stating that they liked learning science very much (81%). However, these rates decreased at the 8th grade level. While 52% of the students who took the exam in the 8th grade agreed "I like learning science very much," with Turkey ranking third in that regard, only 28% agreed "I like learning mathematics very much," with Turkey being ranked eleventh for that statement (TIMSS, 2016). Thus, in lower-secondary school and high school, many students' motivation levels in different STEM subject areas decline and remain low thereafter (Rosenzweig & Wigfield, 2016).

STEM and School Type

Various exams are conducted to determine the literacy levels of students in STEM fields. The Trends in International Mathematics and Science Study (TIMSS) is an international exam that includes questions related to STEM fields (OECD, 2013; TIMSS, 2016). The Program for International Student Assessment (PISA) exam measures 15-year-old students' achievements in reading, mathematics, and science in OECD member countries. In the PISA exam, students are asked questions about real-world problems while the TIMSS exam, on the other hand, consists of questions prepared on the basis of the curriculum for students studying in the 4th and 8th grades. Considering both PISA and TIMSS exam data, it has been determined that the type of school students attend has an effect on their exam scores. Furthermore, when motivation levels for science education were compared between public and private schools, it was found that students in private schools had higher levels of motivation. One of the important aims of STEM education is to incorporate efforts to ensure social justice and equality. In this context, it is expected that the learning outcomes of individuals who have received STEM education should not differ much according to the type of school attended.

STEM and Parental Education Levels

While examining the results of students' success in STEM fields in both national and international exams, parental education levels are also a subject of interest. Considering the 2012 PISA results, students whose parents worked in occupational fields related to science, technology, engineering, or mathematics tended to perform better in mathematics than other students of similar socioeconomic status whose parents worked in different fields (OECD, 2013). An et al. (2018) stated that, in general, among the socioeconomic variables of a given family, the education level of the parents has the greatest influence on the academic achievement of the children, and the influence of family income is relatively weaker. When families participated in the education of their children, emotional involvement was revealed to have the greatest impact on the children's academic STEM achievements with the ability to offset potential negative effects brought about by other family variables.

STEM and Family Income Level

Educated parents spend more time with their children through different stages of their education than less educated parents in activities that provide developmentally appropriate and informal educational opportunities and resources (Chadwell, 2016). Increasing concern is being expressed about disparities in science achievement between children

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from socioeconomically disadvantaged households and their more advantaged peers (Riegle-Crumb & King, 2010). Some studies have identified family income as the most critical variable in achievement gaps in STEM fields, and this gap between children from high- and low-income families has been significantly increasing in recent years (Carrico et al., 2016). Accordingly, students of lower socioeconomic status are less likely to enroll in STEM fields than their peers of higher socioeconomic status (Chachashvili-Bolotin et al., 2016).

Research Problem

In recent years, many studies have been carried out on STEM education. Lower-secondary school marks an important crossroads for examining young people's STEM motivation as students begin to make important decisions about STEM that will shape their educational and career trajectories (Maltese & Tai, 2010; Wyss et al., 2012). However, few studies to date have focused on these motivational processes. STEM education applications were included in the science education program as engineering applications in the 2017-2018 academic year in Turkey. In that process, the need for multidimensional examination of STEM education practices and student motivation levels emerged. Such findings would make it possible to evaluate the effects of demographic characteristics on STEM motivation and examining lower-secondary school students' expectations and values regarding STEM fields may also shed light on the STEM motivations of young people in this critical period (Morales-Chicas et al., 2021). In this study, the STEM motivations of lower-secondary school students in Turkey were examined. Potential differences in lower-secondary school students' STEM motivations according to the variables of gender, place of residence, grade level, school type, mother's education level, father's education level, and family income level were explored.

Research Questions

This study is thought to be important in terms of contributing conceptually and methodologically to future studies on STEM motivation in the context of demographic variables. Answers were accordingly sought to the following questions:

1. Does gender have an effect on motivation in STEM and its dimensions?
2. Does place of residence have an effect on motivation in STEM and its dimensions?
3. Does grade level have an effect on motivation in STEM and its dimensions?
4. Does type of school have an effect on motivation in STEM and its dimensions?
5. Does educational status of the mother have an effect on motivation in STEM and its dimensions?
6. Does educational status of the father have an effect on motivation in STEM and its dimensions?

Research Methodology

General Background

The present research was carried out by using quantitative research method and relational screening model was applied. "Quantitative research uses inquiry strategies such as experiments and surveys and collects data on predetermined tools that provide statistical data" (Creswell, 2003). Screening models are research approaches that aim to describe a past or present situation as it exists. A relational screening model, on the other hand, is a research model that aims to determine the existence and/or degree of co-variance between two or more variables (Karasar, 2012). According to Sukamolson (2007), survey research involves the use of a scientific sampling method with a questionnaire designed to measure the characteristics of a particular population using statistical methods. Survey models aim to examine the co-change occurring between at least two variables (Fraenkel et al., 2012). The present study was conducted during the spring term of the 2021 educational year. The survey was administered to participants between January 2021 and June 2021.

Research Population/Community

Turkey consists of 7 regions and 81 provinces. In this study, an effort was made to conduct research in the largest city of each region. The population of the study consisted of lower-secondary students studying in 12 provinces. In this context, research was conducted in 120 schools selected randomly. The sample of the research was determined

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by random sampling method, 1926 students studying in the lower-secondary schools in the research population were identified, and their participation in the study was ensured on a voluntary basis. The survey created for this study was administered via Google Forms. The characteristics of the participants are listed in Table 1. The variables of gender in two categories (girls and boys), place of residence in three categories (provincial center, district center, and village), grade level in four categories (5th, 6th, 7th, and 8th grades), and school type in four categories (public lower-secondary schools, private lower-secondary schools, religious [imam-hatip] lower-secondary schools, and science and art centers for gifted students [BİLSEM]) were evaluated. Imam-hatip schools provide religious education at lower-secondary and high school levels in Turkey. BİLSEMs are state institutions where gifted students receive education. Students are admitted to these institutions based on their performances on various aptitude and intelligence tests. The education levels of the mothers and fathers were evaluated in five categories (illiterate, primary school, lower-secondary school, high school, university) and family income level was evaluated in six categories (750-1000 Turkish lira [TL], 1001-2000 TL, 2001-3000 TL, 3001-4000 TL, 4001-5000 TL, 5001 and above).

Table 1
Demographic Characteristics of the Participants

Variable	Groups	*n*	%
Gender	Girl	1064	55.2
	Boy	862	44.7
Place of residence	Provincial center	1284	66.6
	District center	598	31.0
	Village	44	2.2
Grade level	5th	494	25.6
	6th	544	28.2
	7th	417	21.6
	8th	471	24.4
School Type	Public lower-secondary school	1680	87.2
	Private lower-secondary school	18	0.9
	Imam-hatip lower-secondary school	203	10.5
	Science and art center (BİLSEM)	37	1.9
Mother's education level	Primary school	529	27.4
	Lower-secondary school	359	18.6
	High school	598	31.0
	University	386	20.0
	Illiterate	54	2.8
Father's education level	Primary school	395	20.5
	Lower-secondary school	317	16.4
	High school	691	35.8
	University	493	25.5
	Illiterate	30	1.5
Family income level	750-1000 TL	160	8.3
	1001-2000 TL	204	10.5
	2001-3000 TL	540	28.0
	3001-4000 TL	363	18.8
	4001-5000 TL	279	14.4
	5001 and above	380	19.7

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Thus, in this study, the dependent variable was STEM motivation, and the independent variables were gender, place of residence, grade level, parental education levels, and family income level.

Ethics

Participants of the study were lower-secondary school students. All participants were asked to complete the survey via Google Forms. All students participated in the study voluntarily as confirmed by their completion of a volunteer participation form. The aim of the study and how the data would be used was explained to the students, and all necessary information was given in the form. It was also clearly stated in the form that participants' personal information would not be shared with anyone.

Data Collection Tools

Two data collection tools were used in this research.

***Personal Information Form*:** A personal information form was used to collect data on gender, place of residence, grade level, school type, mother's education level, father's education level, and family income level.

***STEM Motivation Scale*:** The STEM Motivation Scale was used to determine participants' levels of motivation for science, technology, engineering, and mathematics. The original scale was developed by Luo at al. (2019) as a 4-point Likert-type scale containing 28 items. The Turkish adaptation of that scale was performed by Dönmez (2020). Exploratory and confirmatory factor analyses were used in adapting the scale, and the Turkish version of the scale consists of 4 dimensions and 25 items. The reliability coefficient of the scale was calculated as 0.84.

Data Collection Process

Since face-to-face education was not being carried out due to the COVID-19 pandemic, the data collection tools were administered to students online. An ethics report on the implementation of this research was obtained from Muş Alparslan University and submitted to the MoNE, which granted approval for the implementation of the research. That approval was presented to school directorates that were randomly selected. School principals forwarded the form to teachers, who asked students to participate in the research voluntarily:

Dear participants, this scale has been prepared to examine your motivation and career interests in the fields of science, technology, engineering, and mathematics (STEM). Your answers will be used for the purposes of scientific study. Thank you for your participation and your time.

Data Analysis

Data obtained online were converted into Excel format and then processed in SPSS. The obtained data were subjected to normality testing. The Kolmogorov-Smirnov value was calculated as $p< .05$. The skewness value was -230 and kurtosis was calculated as 350. A value of skewness - kurtosis between -1.0 and +1.0 indicates that the data are normally distributed (Hair et al, 2013). It was accepted that the data showed a normal distribution. For this reason, parametric tests were preferred. The *t*-test was used to determine the effect of gender on STEM motivation. ANOVA testing was used to compare the effects of place of residence, grade level, school type, mother's education level, father's education level, and family income level on STEM motivation. The data were analyzed using the free version of the SPSS 23 package program.

Research Results

STEM Motivation and Gender

Table 2 shows the t-test results for girls and boys related to motivation in the fields of science, technology, engineering, and mathematics. There is a significant difference in favor of boys in the technology dimension ($t = -3.199$, $p < .05$, $\eta 2 = 0.005$) and the engineering dimension ($t = -5.928$, $p < .05$, $\eta 2 = 0.001$). There is no significant difference in the dimensions of science and mathematics. For overall STEM motivation ($t = -2.331$, $p < .05$, $\eta 2 = 0.003$), there was again a significant difference in favor of male students. In Table 2, S, T, E, and M are given to describe the dimensions of the STEM field (science, technology, engineering, and mathematics).

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Table 2
The t-test Results of Participants by Gender

Group		S	T	E	M	STEM Motivation
Girls	*M*	2.70	2.92	2.13	2.70	2.65
Boys		2.67	3.00	2.34	2.68	2.70
	t	1.190	-3.199	-5.928	0.704	-2.331
	p	.23	.01	.001	.48	.02
	η2	0.001	0.005	0.018	0.00	0.003

Note: *S, T, E, and M: Science, technology, engineering, and mathematics.

STEM Motivation and Place of Residence

As seen in Table 3, in the science dimension ($F = 4.248$, $p < .05$, $\eta 2 = 0.004$) and in the technology dimension ($F = 4.491$, $p < .05$, $\eta 2 = 0.005$), there was a significant difference in favor of those living in provincial centers. This significant difference in favor of those living in provincial centers was observed for all areas of STEM motivation ($F = 4.018$, $p < .05$, $\eta 2 = 0.004$). There is no difference in the engineering and mathematics dimensions.

Table 3
ANOVA Table for STEM Motivation among the Participants according to Place of Residence

Group		S	T	E	M	STEM Motivation
Provincial center		2.71	2.98	2.24	2.71	2.69
District center	*M*	2.65	2.92	2.20	2.64	2.63
Village		2.57	2.82	2.13	2.71	2.59
	F	4.248	4.491	0.787	2.642	4.018
	p	.01	.01	.45	.07	.01
	η2	0.004	0.005	0.001	0.003	0.004

Note: *S, T, E, and M: Science, technology, engineering, and mathematics.

STEM Motivation and Type of School

Table 4 presents the ANOVA results regarding the STEM motivations of the participants according to school type. Significant differences were seen among science motivation ($F = 3.678$, $p < .05$, $\eta 2 = 0.008$), technology motivation ($F = 3.497$, $p < .05$, $\eta 2 = 0.007$), and overall STEM motivation ($F = 3.489$, $p < .05$, $\eta 2 = 0.007$), with motivation levels being higher among BİLSEM students and lower among students of imam-hatip schools. No significant differences were found for engineering and mathematics motivation.

Table 4
ANOVA Table for STEM Motivation among the Participants according to School Type

Group		S	T	E	M	STEM Motivation
Public lower-secondary school		2.70	2.97	2.23	2.69	2.68
Private lower-secondary school	*M*	2.73	2.97	2.21	2.79	2.71
Imam-hatip lower-secondary school		2.57	2.86	2.12	2.63	2.57
Science and art center (BİLSEM)		2.89	3.00	2.61	2.90	2.87
	F	3.678	3.497	2.187	1.215	3.489

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Group		S	T	E	M	STEM Motivation
	p	.001	.001	.06	.30	.001
	η2	0.008	0.007	0.005	0.003	0.007

Note: *S, T, E, and M: Science, technology, engineering, and mathematics.

STEM Motivation and Grade Level

Table 5 presents the ANOVA results for STEM motivation levels among students in the 5th, 6th, 7th, and 8th grades. Significant differences existed for science motivation ($F = 7.333$, $p < .05$, $\eta2 = 0.011$), engineering motivation ($F = 3.596$, $p < .05$, $\eta2 = 0.006$), mathematics motivation ($F = 3.955$, $p < .05$, $\eta2 = 0.006$), and overall STEM motivation ($F = 4.033$, $p < .05$, $\eta2 = 0.006$). The science motivation of students in the 6th and 7th grades was higher than that of students in the 5th and 8th grades. The engineering motivation of students in the 5th grade was higher than that of all other considered grade levels. The mathematics motivation of students in the 6th grade was higher than the motivation of students in the 8th grade. When overall STEM motivation is considered, the scores of students in the 5th grade were the highest among all considered grade levels.

Table 5
ANOVA Table for STEM Motivation among the Participants according to Grade Level

Group		S	T	E	M	STEM Motivation
5th	*M*	2.27	2.95	2.31	2.71	2.71
6th		2.69	2.94	2.24	2.73	2.68
7th		2.68	2.99	2.20	2.72	2.68
8th		2.61	2.96	2.21	2.60	2.60
	F	7.333	0.814	3.596	3.955	4.033
	p	0.001	0.48	0.01	0.001	0.001
	η2	0.011	0.001	0.006	0.006	0.006

Note: *S, T, E, and M: Science, technology, engineering, and mathematics.

STEM Motivation and Mother's Education Level

Table 6 presents the ANOVA results for participants' STEM motivations according to maternal education levels. Significant differences can be observed for science motivation ($F = 4.954$, $p < .05$, $\eta2 = 0.010$), engineering motivation ($F = 3.195$, $p < .05$, $\eta2 = 0.007$), and overall STEM motivation ($F = 2.427$, $p < .05$, $\eta2 = 0.04$), while there are no significant differences in students' levels of motivation for technology or mathematics. These findings show that overall STEM motivation increases as the level of the mother's education increases.

Table 6
ANOVA Table for STEM Motivation among the Participants according to Mother's Education Levels

Group		S	T	E	M	STEM Motivation
Illiterate	*M*	2.66	2.90	2.39	2.70	2.68
Primary school		2.64	2.94	2.18	2.67	2.64
Lower-secondary school		2.67	2.97	2.27	2.69	2.68
High school		2.68	2.95	2.18	2.68	2.66
University		2.78	2.98	2.31	2.73	2.73
	F	4.954	0.514	3.195	0.477	2.427

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Group		S	T	E	M	STEM Motivation
	p	.001	.72	.01	.75	.04
	η2	0.010	0.001	0.007	0.001	0.005

Note: *S, T, E, and M: Science, technology, engineering, and mathematics.

STEM Motivation and Father's Education Level

Table 7 presents the ANOVA results for participants' STEM motivations according to paternal education levels. Significant differences were identified for science motivation ($F = 5.976$ $p < .05$, $\eta2 = 0.012$), mathematics motivation ($F = 3.041$, $p < .05$, $\eta2 = 0.006$), and overall STEM motivation ($F = 3.070$, $p < .05$, $\eta2 = 0.006$), but not for technology or engineering. These findings reveal an association between higher levels of paternal education and higher levels of STEM motivation.

Table 7
ANOVA Table for STEM Motivation among the Participants according to Father's Education Levels

Group		S	T	E	M	STEM Motivation
Illiterate		2.67	2.82	2.24	2.78	2.65
Primary school		2.63	2.96	2.18	2.65	2.63
Lower-secondary school	*M*	2.60	2.93	2.19	2.64	2.63
High school		2.71	2.97	2.22	2.67	2.68
University		2.76	2.96	2.29	2.77	2.72
	F	5.976	0.985	1.512	3.041	3.070
	p	.001	.41	.19	.01	.01
	η2	0.012	0.002	0.003	0.006	0.006

Note: *S, T, E, and M: Science, technology, engineering, and mathematics.

STEM Motivation and Family Income Level

Table 8 presents the ANOVA results for participants' levels of STEM motivation according to family income level. There are significant differences in the levels of science motivation ($F = 2.654$, $p < .05$, $\eta2 = 0.007$) and mathematics motivation ($F = 3.026$, $p < .05$, $\eta2 = 0.008$), with motivation in those areas increasing as family income increases. No significant differences are observed, however, for technology, engineering, or overall STEM motivation.

Table 8
ANOVA Table for STEM Motivation among the Participants according to Family Income Levels

Group		S	T	E	M	STEM Motivation
750-1000 TL		2.68	2.95	2.31	2.69	2.68
1001-2000 TL		2.64	2.95	2.25	2.64	2.65
2001-3000 TL		2.65	2.94	2.16	2.68	2.64
3001-4000 TL	*M*	2.68	2.96	2.24	2.69	2.68
4001-5000 TL		2.70	2.96	2.20	2.60	2.65
>5000 TL		2.76	2.97	2.27	2.79	2.73
	F	2.654	0.202	1.520	3.026	1.953
	p	.02	.09	.18	.01	.08
	η2	0.007	0.001	0.004	0.008	0.005

Note: *S, T, E, and M: Science, technology, engineering, and mathematics.

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Discussion

With this study, it has been demonstrated that students' STEM motivations differ according to gender, place of residence, school type, grade level, and parental education levels, but they do not change significantly according to family income level. STEM motivation levels among female students were found to be lower than those of male students in this study. As girls' enthusiasm (Unfried et al., 2015) and career interests (Ünlü & Dokme, 2020) in STEM fields tend to be lower, intervention programs should be organized for girls. Female students may react more strongly to such interventions than male students because they may need more motivational support in these areas due to societal beliefs (Rosenzweig & Wigfield, 2016). Shin et al. (2018) conducted a study with Korean and Indonesian secondary students regarding their career motivations in STEM. They found that the Korean students' gender differences in STEM career motivation were larger than those of the Indonesian students. While the previously observed differences in motivation in favor of male students in the fields of science and mathematics seem to have disappeared, a difference in favor of male students was still observed here in the fields of technology and engineering. The lack of motivation among female students in the fields of technology and engineering may also affect their future career orientations.

For nearly 20 years, mathematics and science achievements were not seen to differ significantly between rural students and non-rural students in national assessments (Anderson & Chang, 2011; Showalter et al., 2017). However, in the present study, a significant difference was observed in students' science motivations according to the family's place of residence, with STEM motivation being lower among students living in rural areas than among those living in cities. Other research conducted in Turkey revealed that career interests also differ between rural and urban students (Karakaya et al., 2018). Decreased STEM motivation among students in rural areas is likely due to problems in accessing resources as a result of regional income inequalities in Turkey. Morris et al. (2021) found results similar to those of the current study. In order to enhance rural students' knowledge of and engagement in STEM, they created a local rural knowledge model. They reported that knowledge was retained better with learners' engagement in STEM through authentic learning experiences and students also engaged more with the wider community during this process. Previous research has furthermore shown that success in STEM fields is more likely to be attributed to gifted status or innate intelligence than success in many other fields (Storage et al., 2016). In the present study, the STEM motivations of gifted students were found to be higher than the motivation levels among other students. The STEM motivations of students enrolled in religiously oriented educational institutions were significantly low. Given that religion and science may have a contentious relationship in both popular discourse and personal opinion, religious affiliation may potentially have a negative impact on students' STEM motivations (Rodriguez et al., 2019).

Students' motivation levels in STEM disciplines have been found to decrease over time (Robinson et al., 2019). Similarly, in this study, a significant decrease in STEM motivation occurred as grade level increased. This decrease in motivation puts older students at risk of lower STEM achievement, which may in turn affect their decisions about taking advanced STEM courses later in their education (Maltese & Tai, 2010; Wang & Eccles, 2013). Therefore, it is recommended that the intensity of STEM intervention programs be increased as the grade level increases. Although many STEM interventions focus on teaching practices in traditional classrooms, the roles that informal settings such as museums and zoos can play in engaging and motivating the next generation of STEM professionals are also of considerable interest (Johnson et al., 2015). Based on this conclusion, it can be said that out-of-school learning activities directly related to STEM education can be conducted to provide STEM motivation both during and after learning and teaching processes. Science centers, industrial institutions, scientific laboratories, zoos, and planetariums can be given as examples of places where STEM activities are carried out. In this context, it should be ensured that students benefit from such places.

In the literature, there are some studies reporting that families with higher levels of parental education are more effective in terms of the permanence of students' interest and success in STEM fields (Dubow et al., 2009; Gayles & Ampaw, 2011). Chachashvili-Bolotin, et al. (2016) stated that students with lower socioeconomic backgrounds, as reflected by lower parental education and family income, expressed lower levels of interest in STEM areas than students with higher socioeconomic backgrounds. In this study, it was similarly determined that STEM motivation increased significantly as the education levels of the parents increased. The reason for this may be that parents with higher levels of education are more interested in their children's academic pursuits and serve as better educational role models. However, there was no significant relationship between family income level and STEM motivation in this study. Similar results were obtained by some authors (Dubow et al., 2009), but other studies found that students from families of low socioeconomic status were less likely to take STEM courses in high school (Chachashvili-Bolotin et al., 2016). For this reason, future research should investigate the barriers that prevent students from low socioeconomic backgrounds from enrolling in STEM courses.

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Conclusions

In the survey conducted for this work with a large sample of lower-secondary school students in Turkey, important results regarding STEM motivation were obtained. The results showed that male students had more STEM motivation than girls. In addition, when the dimensions of STEM were examined, it was seen that the motivation levels of female students in the science and technology dimensions were lower. Considering that students' sustained motivations are effective in STEM career development, policymakers and program developers should focus on educational content that will support STEM motivation.

It was seen in this study that place of residence affected students' STEM motivations. Students residing in city centers had higher levels of STEM motivation, suggesting that students in urban areas may enjoy more educational opportunities in their schools. This finding furthermore reflects the realities of inequality in educational opportunities among city centers, districts, and villages in Turkey. For this reason, intervention programs for students studying in rural areas are needed.

It was furthermore seen that the school types of the participating students affected their levels of motivation for STEM and its dimensions. It seems that religiously oriented educational processes have a particularly negative impact on STEM motivation. Therefore, it is necessary to increase the STEM educational content for students who are receiving religious education. On the other hand, the high levels of STEM motivation among gifted students may be due to individual differences. This could also be considered a result of the educational opportunities supported by the strong infrastructure and plentiful equipment in specific schools for gifted students in Turkey.

As grade level increased, a general decrease in STEM motivation was seen in this work, and it can be expected that students' future orientations toward STEM fields will suffer accordingly. Considering both other studies conducted elsewhere in the world and previous reports prepared in Turkey, the decrease in students' orientations toward STEM careers in correlation with grade level may be attributed to the nature of the exam-oriented education system with a failure to properly address students' STEM interests and needs.

In light of the results outlined here, it is suggested that future studies focus on supportive activities to determine and boost the STEM motivations of teachers who work with or will be working with students of different demographic groups.

Limitations and Recommendations

Several limitations should be considered while interpreting the findings of this study. First, this research is limited to the data obtained from 1926 students receiving formal education in 12 provinces of Turkey. Future research should be carried out with more participants from other provinces of Turkey to increase the validity and reliability of the present findings. Second, in the context of school type, the lower numbers of students attending imam-hatip lower-secondary schools and science and art centers (BİLSEM) compared to other school types is another limitation of this work. Future studies should strive to diversify the types of schools and include more students from each school type. Third, an online questionnaire was used in the data collection process due to the COVID-19 pandemic. Therefore, students who did not have internet access could not participate in this research. Finally, this study has provided general information based on quantitative research methods. To obtain more detailed information about STEM motivation levels over time, a multidimensional perspective should be provided by supporting quantitative data with qualitative data.

Conflict Interest Statement

The authors declare that they have no conflict of interest.

References

Akgündüz, D., Aydeniz, M., Çakmakçı, G., Çavaş, B., Corlu, M. S., Öner, T., &. Özdemir, S. (2015). *STEM eğitimi Türkiye raporu: Günün modası mı yoksa gereksinim mi?* [A report on STEM Education in Turkey: A provisional agenda or a necessity?] [White Paper]. Aydın Üniversitesi.

Anderson, R., & Chang, B. (2011). Mathematics course-taking in rural high schools. *Journal of Research in Rural Education, 26*(1), 1-10. https://eric.ed.gov/?id=EJ914010

Aydın, G., Saka, M., & Güzel, 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. http://dx.doi.org/10.17860/mersinefd.290319

https://doi.org/10.33225/jbse/22.21.38

An, G., Wang, J., Yang, Y., & Du, X. (2018). A study on the effects to students' STEM academic achievement with Chinese parents' participative styles in school education. *Educational Sciences: Theory & Practice, 19*(1), 41-54. https://doi.org/10.12738/estp.2019.1.0180

Biggs, J., & Tang, C. (2011). *Teaching for quality learning at university*. McGraw-Hill.

Bybee, R. W. (2013). *The case for STEM education: Challenges and opportunities*. NSTA press.

Chachashvili-Bolotin, S., Milner-Bolotin, M., & Lissitsa, S. (2016). Examination of factors predicting secondary students' interest in tertiary STEM education. *International Journal of Science Education, 38*(3), 366-390. https://doi.org/10.1080/09500693.2016.1143137

Chavatzia, T. (2017). *Cracking the code: Girls' and women's education in science, technology, engineering, and mathematics (STEM)*. UNESCO.

Carrico, C., Murzi, H., & Matusovich, H. (2016, October). The roles of socializers in career choice decisions for high school students in rural central Appalachia: "Who's doing what?". *In 2016 IEEE Frontiers in Education Conference (FIE)* (pp. 1-6). IEEE.

Chadwell, B. (2016). *The effect of socio-economic status and gender on high school student perceptions about career and technical education* (Doctoral dissertation). Liberty University.

Craig, C., Verma, R., Stokes, D., Evans, P., & Abrol, B. (2018). The influence of parents on undergraduate and graduate students' entering the STEM discipline sand STEM careers. *International Journal of Science Education, 40*(6), 621-643. https://doi.org/10.1080/09500693.2018.1431853

Creswell, J. (2003). *Research design: Qualitative, quantitative and mixed methods approach* (2nd ed.). SAGE Publications.

Dönmez, İ. (2020). Adaptation of STEM motivation scale into Turkish: Validity and reliability study. *YYU Journal of Education Faculty, 17*(1), 486-510. https://doi.org/10.33711/yyuefd.693825

Dubow, E. F., P. Boxer, & L. R. Huesmann. (2009). Long-term effects of parents' education on children's educational and occupational success: mediation by family interactions, child aggression, and teenage aspirations. *Merrill-Palmer Quarterly, 55*(3), 224. https://doi:10.1353/mpq.0.0030

Entwistle, N. & McCune, V. (2013). The disposition to understand for oneself at university: Integrating learning processes with motivation and metacognition. *The British Journal of Educational Psychology, 83*(Pt 2), 267–279. https://doi.org/10.1111/bjep.12010

Fadzli, S., Yahaya, J., Deraman, A., Hamdan, A. R., Halim, L., Yahaya, N., & Z., Zahari, M. S. M., & Rais, I. A. I. (2020). Environment based virtual interaction to enhance motivation of STEM education: The qualitative interview design and analysis. *Education and Information Technologies, 25*(2), 775-790.https://doi.org/10.1007/s10639-019-09996-y

Fox, M. F., Sonnert, G., & Nikiforova, I. (2011). Programs founder graduate women in science and engineering: Issues, problems, and solutions. *Gender & Society, 25*, 589–615. https://doi.org/10.1177/0891243211416809

Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2012). *How to design and evaluate research in education*. McGrawHill.

Freeman, K. E., Alston, S. T., & Winborne, D. G. (2015). Do learning communities enhance the quality of students' learning and motivation in STEM? *The Journal of Negro Education, 77*(3), 227-240.

Gayles, J. G., & Ampaw, F. D. (2011). Gender matters: An examination of differential effects of the college experience on degree attainment in STEM. *New Directions for Institutional Research, 152*, 19-25. https://doi.org/10.1002/ir.405

Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., & Tatham, R. L. (2013). *Multivariate data analysis*. Pearson Education.

Hill, C., Corbett, C., & St Rose, A. (2010). *Why so few? Women in science, technology, engineering, and mathematics*. American Association of University Women.

Ivie, R., & Tesfaye, C. L. (2012). Women in physics: A tale of limits. *Physics Today, 65*(2), 47–50. http://dx.doi.org/10.1063/PT.3.1439

Jaafar, W, N, W. & Maat, S. M. (2020). The relationship between self-efficacy and motivation with STEM Education: A systematic literature review. *International Journal of Modern Education (IJMOE), 2*(4), 19-29. https://doi.org/10.35631/IJMOE.24002

Johnson, B., S. Thomas, N. Ardoin, & M. Saunders. (2015). Investigating the long-term effects of informal science learning at zoos and aquariums. *International Zoo Educators Association Journal, 53*(2), 48–51.

Karakaya, F., Avgın, S. & Yılmaz, M. (2018). Middle school students' interest in science-technology engineering and mathematics (STEM) professions. *Ihlara Journal of Education Research, 3*(1), 36-53.

Karasar, N. (2012). *Bilimsel araştırma yöntemi* [Scientific research method]. Nobel Publishing Group.

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. https://doi.org/10.1002/tea.21200

LeGrand, J. (2013). *Exploring gender differences across elementary, middle, and high school students' science and math attitudes and interest*. (Doctoral dissertation). Northeastern University.

Leon, M., Juan, L., Nunez, B. & Liew, J. (2015). Self-determination and STEM education: Effects of autonomy, motivation, and self-regulated learning on high school math achievement. *Learning and Individual Differences, 43,* 156-163. https://doi.org/10.1016/j.lindif.2015.08.017

Luo, T., Wang, J., Liu, X., & Zhou, J. (2019). Development and application of a scale to measure students' STEM continuing motivation. *International Journal of Science Education, 41*(14), 1885-1904. https://doi.org/10.1080/09500693.2019.1647472

Maltese, A. V., & Tai, R. H. (2010). Eyeballs in the fridge: Sources of early interest in science. *International Journal of Science Education, 32*(5), 669–685. https://doi.org/10.1080/09500690902792385

Maltese, A. V., Melki, C. S., & Wiebke, H. L. (2014). The nature of experiences responsible for the generation and maintenance of interest in STEM. *Science Education, 98*(6), 937-962. https://doi.org/10.1002/sce.21132

Morales-Chicas, J., Ortiz, J., Tanimura, D. M., & Kouyoumdjian, C. (2021). Understanding latino boys' motivation to pursue STEM while navigating school inequalities. *Journal of Latinos and Education*. https://doi.org/10.1080/15348431.2021.1944864

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Morris, J., Slater, E., Fitzgerald, M., Lummis, G. W., & Etten, E. V. (2021). Using local rural knowledge to enhance STEM learning for gifted and talented students in Australia. *Research in Science Education 51*, 61–79.

Mutambara, D., & Bayaga, A. (2021). Determinants of mobile learning acceptance for STEM education in rural areas. *Computers & Education, 160*, 1-16. https://doi.org/10.1016/j.compedu.2020.104010

O'Dea, R. E., Lagisz, M., Jennions, M. D., & Nakagawa, S. (2018). Gender differences in individual variation in academic grades fail to fit expected patterns for STEM. *Nature Communications, 9*(1), 1-8. https://doi.org/10.1038/s41467-018-06292-0

Riegle-Crumb, C., & King, B. (2010). Questioning a white male advantage in science, technology, engineering and mathematics: Examining disparities in college major by gender and race/ethnicity. *Educational Researcher, 39*(9), 656–664. https://doi.org/10.3102/0013189X10391657

Robinson, K. A., Perez, T., Carmel, J. H., & Linnenbrink-Garcia, L. (2019). Science identity development trajectories in a gateway college chemistry course: Predictors and relations to achievement and STEM pursuit. *Contemporary Educational Psychology, 56*, 180–192. https://doi.org/10.1016/j.cedpsych.2019.01.004.

Rodriguez, S. L., Friedensen, R., Marron, T., & Bartlett, M. (2019). Latina undergraduate students in STEM: The role of religious beliefs and STEM identity. *Journal of College and Character*, *20*(1), 25-46. https://doi.org/10.1080/2194587X.2018.1559198

Master, A., & Meltzoff, A. N. (2020). Cultural stereotypes and sense of belonging contribute to gender gaps in STEM. *International Journal of Gender, Science, and Technology, 12*(1), 152-198.

MoNE [Ministry of National Education]. (2018). Fen Bilimleri Dersi Öğretim Programı (İlkokul ve Ortaokul 1, 2, 3, 4, 5, 6, 7, ve 8. Sınıflar) [Science Curriculum (Primary and Secondary School 1, 2, 3, 4, 5, 6, 7, and 8th Grades)]. Ankara.

Murphy, M. C., Steele, C. & Gross, J. (2007). Signaling threat: How situational cues affect women in math, science, and engineering settings. *Psychological Science, 18*, 879-885. https://doi.org/10.1111/j.1467- 9280.2007.01995.x

National Research Council [NRC] (2011). *Successful K-12 STEM education: identifying effective approaches in science, technology, engineering, and mathematics. Committee on Highly Successful Schools or Programs for K-12 STEM Education*. The National Academies Press.

OECD [Organisation for Economic Co-operation and Development] (2013). The role of families in shaping students' engagement, drive and self-beliefs. https://www.oecd.org/pisa/keyfindings/PISA2012-Vol3-Chap6.pdf

Potvin, P., & A. Hasni. (2014). Interest, motivation and attitude towards science and technology at k-12 levels: a systematic review of 12 years of educational research. *Studies in Science Education 50* (1), 85–129. https://doi.org/10.1080/03057267.2014.881626

Ricks, M. M. (2006). *A study of the impact of an informal science education program on middle school students' science knowledge, science attitude, STEM high school and college course selections, and career decisions. (Doctoral dissertation)*. The University of Texas.

Ritz, J. M., & Fan, S. C. (2015). STEM and technology education: International state-of-the-art. *International Journal of Technology and Design Education, 25*(4), 429-451. https://doi.org/10.1007/s10798-014-9290-z

Rosenzweig, E. Q., & Wigfield, A. (2016). STEM motivation interventions for adolescents: A promising start, but further to go. *Educational Psychologist, 51*(2), 146-163. https://doi.org/10.1080/00461520.2016.1154792

Shin, S., Rachmatullah, A., Roshayanti, F., Ha, M & Lee, J. K. (2018). Career motivation of secondary students in STEM: A cross-cultural study between Korea and Indonesia. *International Journal for Educational and Vocational Guidance volume*, *18*, 203–231. https://doi.org/10.1007/s10775-017-9355-0

Showalter, D., Klein, R., Johnson, J., & Hartman, S. L. (2017). *Why rural matters 2015-2016: understanding the changing landscape*. A Report of the Rural School and Community Trust. Rural School and Community Trust.

Smith, E. (2011). Women into science and engineering? Gendered participation in higher education STEM subjects. *British Educational Research Journal, 37*(6), 993–1014. https://doi.org/10.1080/01411926.2010.515019

Sukamolson, S. (2007). Fundamentals of quantitative research. *Language Institute Chulalongkorn University, 1*(3), 1-20.

Storage, D., Horne, Z., Cimpian, A., & Leslie, S. J. (2016). The frequency of "brilliant" and "genius" in teaching evaluations predicts the representation of women and African Americans across fields. *PloS one, 11*(3), 1-17. https://doi.org/10.1371/journal.pone.0150194

TIMSS [International Association for the Evaluation of Educational Achievement). (2016). TIMSS 2015 and TIMSS advanced 2015 International results.

TUSIAD [Turkish Industry and Business Association]. (2017). STEM requirements in Turkey towards to 2023. https://www.pwc.com.tr/tr/gundem/dijital/2023e-dogru-turkiyede-stem-gereksinimi.htm

TÜBİTAK [Scientific and Technological Research Council of Turkey]. (2004). National Science and Technology Policies 2003-2023 Strategy Document. https://www.tubitak.gov.tr/tubitak_content_files/vizyon2023/Vizyon2023_Strateji_Belgesi.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. https://doi.org/0734282915571160

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.

Ünlü, Z. K., & 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

Wang, M. T., & Eccles, J. S. (2013). School context, achievement motivation, and academic engagement: A longitudinal study of school engagement using a multidimensional perspective. *Learning and Instruction, 28*, 12-23. https://doi.org/10.1016/j.learninstruc.2013.04.002

https://doi.org/10.33225/jbse/22.21.38

Wyss, V. L., Heulskamp, D., & Siebert, C. J. (2012). Increasing middle school student interest in STEM careers with videos of scientists. *International Journal of Environmental & Science Education, 7(*4), 501–522.

Xu, Y. J. (2008). Gender disparity in STEM disciplines: A study of faculty attrition and turn over intentions. *Research in Higher Education, 49*(7), 607-624. https://doi.org/10.1007/s11162-008-9097-4

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