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The Effect of Teachers' Attitudes Towards and Self-Efficacy Beliefs Regarding STEM Education on Students' STEM Career Interests

Kaan Demirkol[1], Büşra Kartal[2]*, Adem Taşdemir[3]

[1]Ministry of National Education, Kırşehir, Turkey
[2]Department of Mathematics and Science Education, Faculty of Education, Kırşehir Ahi Evran University, Kırşehir, Turkey
[3]Department of Basic Education, Faculty of Education, Kırşehir Ahi Evran University, Kırşehir, Turkey

*Corresponding author: busra.kartal@ahievran.edu.tr

ABSTRACT High-quality Science, Technology, Engineering, and Mathematics (STEM) education provides unique opportunities for students' futures. STEM education requires integrating multiple disciplines and promotes students' problem-solving skills when engaging with real-world problems like engineers. Teachers have prominent roles in helping students develop basic concepts, connect their interests to their abilities, and sustain their curiosity from the early years. The present study used a predictive correlational survey design to investigate students' STEM career interests and the effects of teacher-related variables: teacher attitudes and self-efficacy beliefs. The participants were 421 middle school students and 160 teachers randomly selected from the target population. STEM Attitudes Scale and Teacher Self-Efficacy Scale for STEM Practice were used to collect data from teachers, and STEM Career Interest Scale (STEM-CIS) was used for data collection from students. Normality assumptions were tested, and parametric tests were used. One sample t-test was used to compare students' observed mean scores to the expected mean scores and multiple linear regression to investigate the predictivity of teacher attitudes and self-efficacy beliefs on student interests. The results revealed positive weak, and moderate relationships between teacher attitudes, self-efficacy beliefs, and student interests. Additionally, teacher efficacy beliefs had stronger predictivity on student interests than attitudes had.

Keywords STEM education, STEM career interest, Teacher STEM attitudes, Teacher STEM self-efficacy

1. INTRODUCTION

STEM education encourages students to apply their knowledge of science, technology, engineering, and mathematics to real-life situations, creates an authentic learning environment, improves students' problem-solving and higher-order thinking skills and technology literacy, and increases achievement in science and mathematics (Brown, Brown, Reardon & Merrill, 2011; Moore et al., 2014). Integrated STEM also promotes life quality (Bahar & Adıgüzel, 2016) since it attempts to use the knowledge and concepts of STEM disciplines simultaneously and find the solution to real-life problems such as global climate change, the biodiversity crisis, and energy production (Cheng, Antonenko, Ritzhaupt, & MacFadden, 2021; Nadelson & Seifert, 2017). The current global economy is growing exponentially with the tremendous technological developments, which challenges nations to prepare skilled experts to promote technological developments, research, and innovation (Kier, Blanchard, Osborne & Albert, 2014). STEM workforce promotes the leadership of nations in the world economy (Bahar & Adıgüzel, 2016; Christensen, Knezek, & Tyler-Wood, 2015). The call to prepare STEM-talented people has been addressed worldwide to meet the demand for STEM-related fields (Cerinsek, Hribar, Glodez & Dolinsek, 2013; Chachashvili-Bolotin, Milner-Bolotin & Lissitsa, 2016; Kier, Blanchard, Osborne & Albert, 2014; Knowles, Kelley, & Holland, 2018; Regan & DeWitt, 2015; Wang & Degol, 2013). However, employers still have difficulty finding STEM-qualified individuals (Kier, Blanchard, Osborne & Albert, 2014).

Most governments endeavored to promote STEM education to increase the number of STEM employees since STEM determines the nations' future (Bahar & Adıgüzel, 2016; Cheng, Antonenko, Ritzhaupt, & MacFadden, 2021). Education systems need a shift to improve STEM literacy and pursue students to choose STEM careers (Bahar & Adıgüzel, 2016; Cheng, Antonenko, Ritzhaupt, & MacFadden, 2021; Tey, Moses,

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& Cheah, 2020). Turkey has initiatives to fill the vacancies in STEM fields. The exchange programs providing opportunities to motivate students to pursue a STEM career, the industry-college partnerships, and the scholarship programs supporting well-performing students to choose STEM careers are valuable examples of the initiatives (Bahar & Adıgüzel, 2016). In addition, the Vision 2023 Project, the Ministry of National Education, emphasized STEM education and STEM-related fields. However, the Turkish Industry and Business Association (TUSIAD) published a report in 2017 and addressed that 31% of the requirements in STEM fields employment will not be met by 2023(TUSIAD, 2022). Therefore, Turkey should effectively integrate STEM into its education system to meet the need for STEM fields (Koyunlu-Ünlü & Dökme, 2020).

The shortage in STEM fields has sparked researchers' interest in the factors influencing students' STEM career interests. A large and growing body of literature has investigated the factors influencing students' interest in STEM careers (Koyunlu-Ünlü & Dökme, 2020). However, given the importance of the STEM workforce, research examining the factors influencing students' choosing a STEM career is still required (Christensen, Knezek, & Tyler-Wood, 2015). To our knowledge, none of the research investigated the effect of teachers' STEM attitudes and self-efficacy beliefs on their students' STEM career interests. Therefore, the primary purpose of the present study is to reveal the extent to which middle school teachers' attitudes towards and self-efficacy regarding STEM education contribute to students' STEM career interests. The following sections provide information about students' interest in STEM careers and teachers' STEM attitudes and self-efficacy beliefs.

1.1 Theoretical Framework

1.1.1 Students' STEM Career Interests

STEM career interest is associated with students' intention to pursue a STEM career (Cheng, Antonenko, Ritzhaupt, & MacFadden, 2021; Christensen & Knezek, 2017). Individuals seeking a STEM degree make this choice before entering college (Wang & Degol, 2013). The decline in the number of students pursuing a STEM career leads to a gap between the number of STEM employees needed and the STEM graduates (Knowles, Kelley, & Holland, 2018). This shortage complicates countries to remain competitive in the global economy. Therefore, identifying the trends in students' STEM career interests has become essential to promoting education systems to increase students' STEM career interests.

Many researchers have used several theoretical frameworks to identify and understand the factors influencing STEM career interest. The Social Cognitive Career Theory (SCCT), developed by Lent, Brown & Hackett (1994), is one of the most commonly used frameworks in STEM career interest (Chachashvili-Bolotin, Milner-Bolotin & Lissitsa, 2016). The SCCT assumes that beliefs and personal and environmental factors influence students' career interests, choices, and success. Self-efficacy, outcome expectations, personal backgrounds, and contextual supports/barriers are the major factors playing a vital role in career interest and choice within the framework of the SCCT (Bahar & Adıgüzel, 2016; Chachashvili-Bolotin, Milner-Bolotin & Lissitsa, 2016; Kier, Blanchard, Osborne & Albert, 2014). According to SCCT, students are more likely to choose a subject or a career if they have strong self-efficacy and positive outcome expectations in that subject (Chachashvili-Bolotin, Milner-Bolotin & Lissitsa, 2016). Thus, the experiences in school years increasing students' efficacy in STEM fields have become vital in attracting students' interest in STEM careers.

The other framework, the expectancy-value theory, is also developed to understand educational choices such as choosing a STEM subject or pursuing a STEM career, which asserts that individuals' STEM career choice decision depends on their expectation regarding STEM success and their perceived value of STEM fields (Eccles et al., 1983; Eccles & Wigfield, 2002). According to expectancy-value theory, social influences from parents, teachers, and peers are important in shaping individuals' educational choices and developing motivational beliefs regarding STEM careers (Bahar & Adıgüzel, 2016; Cerinsek, Hribar, Glodez & Dolinsek, 2013; Sjaastad, 2012; Wang & Degol, 2013). The influential factors in choosing STEM careers may be divided into social, motivational, and educational factors (Nugent et al., 2015). Holland (1985) pointed out that personality and the environment are crucial factors in career choice. Interest in STEM careers is related to students' self-efficacy, interest, task-value, and long-term life goals influenced by their characteristics and experiences. The social expectation is a prominent factor significantly influencing STEM career interest. Role models in students' families and schools influence their career choice (Bahar & Adıgüzel, 2016). Both frameworks propose that students should positively value STEM fields and believe they can do STEM fields with support from their teachers, peers, and parents to pursue a STEM career.

Identifying the trends in students' interest in STEM careers would contribute to integrating STEM education in schools (Koyunlu-Ünlü & Dökme, 2020). The literature on STEM career interests provides detailed descriptions regarding background information such as age, gender, sociocultural level, parents' educational level, and academic achievement. The middle school period is crucial for students to choose STEM careers (Cerinsek, Hribar, Glodez & Dolinsek, 2013; Cheng, Antonenko, Ritzhaupt, & MacFadden, 2021). Students will be more interested in STEM subjects at their tertiary education and more likely to pursue a STEM career if they experience STEM courses or programs in the early years of their secondary schooling

(Murcia, Pepper, & Williams, 2020; Sahin, Oren, Wilson, Hubert, & Capraro, 2015). Besides, the interest in STEM careers declines as students grow up (Regan & DeWitt, 2015). Thus, early childhood, primary, and middle school education have a crucial contribution to sustaining the STEM pipeline.

Gender biases in STEM fields have attracted considerable interest from a vast majority of studies (Chachashvili-Bolotin, Milner-Bolotin & Lissitsa, 2016; Cheng, Antonenko, Ritzhaupt, & MacFadden, 2021; Koyunlu-Ünlü & Dökme, 2020). Even though girls and boys have similar academic performance in STEM disciplines, the difference mainly occurs in their STEM career interests (Cerinsek, Hribar, Glodez & Dolinsek, 2013; Ing & Nylund-Gibson, 2013). The sociocultural norms, adopting the idea that STEM careers are more appropriate for men than for women (Capobianco, Diefes-Dux, Mena & Weller, 2011) and hinder women from marrying and having a family (Kier, Blanchard, Osborne & Albert, 2014), are influential in women's interest in STEM careers. The gender differences in STEM interests mainly occur after middle school (Christensen, Knezek, & Tyler-Wood, 2015). The early exposure to STEM activities or projects might also eliminate the women's underrepresentation in STEM fields (Christensen & Knezek, 2017). Therefore, teachers must encourage females to STEM careers (Christensen, Knezek, & Tyler-Wood, 2015).

Women and students with low socioeconomic status are underrepresented in tertiary STEM courses and STEM careers (Chachashvili-Bolotin, Milner-Bolotin & Lissitsa, 2016). Addressing this problem and encouraging these groups to further STEM education and careers would increase the pipeline of students who will choose STEM subjects and careers. Family education status is also influential in students' interest in STEM careers. Students whose parents have higher education levels might indicate high levels of interest in science (Dabney, Tai, & Scott, 2016), science competency (Chi, Wang, Liu, & Zhu, 2017), and mathematics achievement (OECD, 2014). However, research also revealed that low socioeconomic levels of students did not affect their interest in STEM careers (Lichtenberger & George-Jackson, 2013). Although the socioeconomic status and parents' educational level lead to differences in students' interests, high-quality teaching might help the underrepresented groups close the gap between them and others.

Issues about teaching and learning also influence career interest and choice. The school experiences help better understand the facets related to STEM careers (Regan & DeWitt, 2015). Cerinsek, Hribar, Glodez & Dolinsek (2013) inquired about the key factors and schools and out-of-school experiences influencing students' choice of studying STEM. STEM achievement, exposure to STEM disciplines, and attending STEM clubs or courses are objective factors investigated by many researchers to reveal what influences students' interest in and choice of STEM careers (Bahar & Adıgüzel, 2016; Chachashvili-Bolotin, Milner-Bolotin & Lissitsa, 2016). Attending after-school activities increases students' interest in STEM careers (Blanchard, Gutierrez, Hoyle, Painter, & Ragan, 2018). However, the classroom structures have a performance-goal structure when students transition to secondary and higher education. It is known that the performance-goal classroom structure does not promote their competence and mastery (Wang & Degol, 2013). This may be why the interest in STEM careers decreases as the students' grade levels increase.

The lack of teaching quality in science and mathematics in K-12 education and the lack of social support from teachers or parents might hesitate students from pursuing STEM careers (Kier, Blanchard, Osborne & Albert, 2014). However, teachers are prominent in interest in STEM (Regan & DeWitt, 2015), and the variety of the teaching methods they employ are associated with their students' motivation and enjoyment (Christensen, Knezek & Tyler-Wood, 2015; Hapmden-Thompson & Benntett, 2013). Teachers act as a model for students to display what to do with STEM and provide a positive learning environment in STEM education. They also help their students define their goals and discover their abilities regarding STEM (Sjaastad, 2012). In addition, good teachers are socializers, positively influencing students' STEM careers and course interests (Cerinsek, Hribar, Glodez & Dolinsek, 2013; Sjaastad, 2012). Therefore, the quality of teaching can influence students' interest in STEM careers (Koyunlu-Ünlü & Dökme, 2020; Regan & DeWitt, 2015). High-quality and motivating teachers positively impact high school students' decisions to pursue a STEM degree. Most of the research (Bahar & Adıgüzel, 2016; Christensen, Knezek, & Tyler-Wood, 2015; Knowles, Kelley, & Holland, 2018) revealed the impact of teachers on STEM career interest from student-reported data. Unlike these researchers, we investigated the relationships between teacher-reported attitudes and efficacy beliefs and student-reported STEM career interests. Therefore, the following section is regarding teachers' roles, attitudes, and perceived efficacy beliefs in STEM education.

1.1.2 Teachers' Attitudes Towards and Self-efficacy Beliefs Regarding STEM Education

Teachers undoubtedly have a significant role in student interest in and understanding of STEM careers, especially for female students who frequently reported the more substantial influence of family, teachers, and peers on their STEM interests (Brown, Concannon, Marx, Donaldson, & Black, 2016; Cerinsek, Hribar, Glodez & Dolinsek, 2013; Knowles, Kelley, & Holland, 2018). The influence of teachers on students' STEM career interests begins at the middle school level (Regan & DeWitt, 2015). Students would tend to connect their interests and competencies to

STEM fields when their teachers allow them to consider STEM fields' goals, opportunities, and outcomes (Kier, Blanchard, Osborne & Albert, 2014). Therefore, teachers should develop STEM-focused courses to provide students opportunities to observe STEM professionals, engage students with hands-on activities, and increase students' awareness of STEM careers (Bahar & Adıgüzel, 2016). It is known that developing such an engaging course is closely related to teachers' beliefs and attitudes (Swars, 2005).

Teacher efficacy is a teacher's judgment of their knowledge and skills about teaching and the extent to which he/she would train students effectively (Guskey & Passaro, 1984). Teachers' high efficacy regarding STEM will increase their willingness to implement STEM activities in their teaching practices (Tschannen-Moran & Hoy, 2001). An efficacious teacher's teaching practice increase students' self-efficacy beliefs, achievement, and motivation regarding science and mathematics (Işıksal-Bostan, 2016; Tschannen-Moran & Hoy, 2001) which are positive influencers of the STEM career interest (Chachashvili-Bolotin, Milner-Bolotin & Lissitsa, 2016; Kier, Blanchard, Osborne & Albert, 2014; Wang & Degol, 2013). Efficacious teachers might emphasize a mastery-goal structure in their classrooms, encouraging their students to increase their mastery and competency in STEM fields (Wang & Degol, 2013). As a result, students would feel more confident, enthusiastic, and interested, promote their higher-order thinking skills, and take responsibility for their learning, and thus their STEM career interest would increase (Chachashvili-Bolotin, Milner-Bolotin & Lissitsa, 2016; Kier, Blanchard, Osborne & Albert, 2014; Rimm-Kaufman & Sawyer, 2004).

Teachers' efficacy beliefs and attitudes regarding STEM education form a theoretical basis for creating a learning environment with a mastery-goal structure (Rimm-Kaufman & Sawyer, 2004). Teachers' efficacy beliefs are closely related to their attitudes and in turn, their instructional behaviors regarding STEM (Dong, Wang, Yang & Kurup, 2020). Teachers with high levels of efficacy for STEM implementation and positive attitudes towards STEM education are more likely to integrate STEM activities into their teaching practices (Al Salami, Makela & De Miranda, 2017). Teacher attitudes towards STEM education, including teacher perceptions regarding the value of STEM education and anxiety towards STEM education, have crucial importance in teachers' decisions on integrating STEM activities into their teaching practices (Kurup, Li, Powell, & Brown, 2019; Thibaut, Knipprath, Dehaene, & Depaepe, 2018). Teachers' positive STEM attitudes also increase their students' attitudes towards and motivation for STEM and vice versa; negative attitudes develop negative student attitudes toward STEM (Nedelson et al., 2013). Negative attitudes will also hinder teachers from implementing STEM (Al Salami, Makela & De Miranda, 2017). Considering the close relationship between teacher efficacy and attitudes, we examined the effect of both constructs on students' STEM career interests.

This study deals with teachers' STEM attitudes and self-efficacy beliefs on students' STEM career interests. There are several important areas where this study makes an original contribution to students' STEM career interests. Firstly, the present study related student-reported STEM career interests to teacher-reported attitudes and self-efficacy beliefs, which is also not yet evident in the literature. There is evidence indicating students reporting about the positive impact of their teachers on their career interests (Bahar & Adıgüzel, 2016; Christensen, Knezek & Tyler-Wood, 2015; Knowles, Kelley, & Holland, 2018). However, these findings stemmed from student-reported data. This study addressed the gap in the relationship between teachers' self-reported motivational orientations and students' self-reported career interests. Secondly, the results might promote developing professional development programs for middle school mathematics and science teachers. The research questions guiding data collection and analysis are as follows:

1. What are the students' interests in STEM careers?
2. Are there relationships between students' STEM career interests and teachers' STEM attitudes and self-efficacy beliefs?
3. Do teachers' STEM attitudes and self-efficacy beliefs predict students' STEM career interests?

2. METHOD

This study employs quantitative data collection tools and analysis and utilizes a correlational survey design. Correlational survey designs aim to reveal the differences in the dependent variable based on various independent variables and describe the trends. The description of the trends is quantitative and can be provided based on data collected from a sample selected as representative as possible from the target population (Cohen, Manion, & Morrison, 2017). Correlational research helps explain human behavior, predict possible outcomes, and reveal to what extent two or more variables are related (Fraenkel, Wallen, Hyun, 2012). Firstly, we describe teachers' STEM attitudes and self-efficacy beliefs and students' STEM career interests. Then, we investigated whether teachers' STEM attitudes and self-efficacy beliefs predict students' STEM career interests.

2.1 Participants

The study's target population comprised the middle school students and their mathematics and science teachers in a province of Central Anatolia. The target population was stratified based on maximum variety, and participant teachers and students were selected randomly from the strata. The school location, students' grade levels, gender, teachers' teaching subject, teaching experience, educational levels, and STEM implementation experiences were considered in constructing the strata to provide the variety of the participants.

A priori sample size was determined through a G-Power analysis using the benchmarks for the effect size of .4, power set at .95, and alpha of .05. The power analysis revealed that a minimum sample size of 121 was enough for this study to achieve adequate power in detecting any statistically significant differences. A sufficient sample size is crucial for research validity, meaning that the scores' interpretations are meaningful, valid, and valuable (Creswell, 2012). The study group is expected to represent the population in many aspects. The participants were 421 middle school students and 160 mathematics and science teacher, indicating that the study's sample is enough to generalize findings to the target population. The students' demographic backgrounds are given in Table 1.

Table 1 Middle school students' demographic backgrounds

Characteristics	N	%
Gender		
Girl	250	59.4
Boy	171	40.6
Grade level		
5. Grade	54	12.8
6. Grade	96	22.8
7. Grade	146	34.7
8. Grade	125	29.7
Mother's Educational level		
Primary school	106	25.2
Middle school	88	20.9
High School	148	35.1
Bachelor's degree	79	18.8
Father's Educational level		
Primary school	82	19.5
Middle school	64	15.2
High School	138	32.8
Bachelor's degree	137	32.5
Family Income		
3.000 TL and below	173	41.1
3001 TL - 6000 TL	158	37.5
6001 TL - 9000 TL	56	13.3
9000 TL and above	34	8.1
Total	421	100

Four hundred twenty-one students participated in the study. Most of the respondents were female (59.4%). Of the 421 respondents, 12.8% were fifth, 22.8% were sixth, 34.7% were seventh, and 29.7% were eighth. Table 1 indicates that students mostly were from medium or low socioeconomic levels. The parents mostly had a high school degree. Nearly half of the students' family income (41.1%) was 3000 TL and below. The demographic backgrounds of the participant teachers are given in Table 2.

Table 2 Teachers' demographic backgrounds

Characteristics	N	%
Gender		
Female	59	36.9
Male	101	63.1
Teaching Subject		
Science	80	50
Mathematics	80	50
School Type		
Public school	148	92.5
Private school	12	7.5
Educational Level		
Bachelor's degree	147	91.9
Master's degree and above	13	8.1
Teaching Experience		
1-5 years	24	15
6-10 years	42	26.3
11-15 years	56	35
16 years and above	38	23.7
Total	160	100

Most respondents were male (63.1%) and had a bachelor's degree (91.9%). Of the 160 teacher participants, 35% had a teaching experience of 16 years and above.

2.2 Data Collection Tools

The data collection tools contained a variety of measures on teachers' STEM attitudes and self-efficacy beliefs and students' STEM career interests. Students' data were collected via the STEM Career Interest Scale (STEM-CIS) and demographics questionnaire, and teachers' data via the STEM Attitudes Scale, Teacher Self-Efficacy Scale for STEM Practice, and a demographics questionnaire. For the current study, the outcome variables were students' STEM career interests, and the predictors were teachers' STEM attitudes and self-efficacy beliefs.

2.2.1 Demographic Questionnaire for Students and Teachers

The questionnaire included items developed by the researchers to identify students' demographic variables (gender, mother's and father's educational level, family income, etc.) and teachers' background information (gender, teaching subject, years of teaching experience, and educational level). The demographic variables were determined based on the literature, identifying the variables stated as influential in teachers' attitudes and beliefs and students' interests (Aydın, Saka, & Guzey, 2017; Xie, Fang, & Shauman, 2015).

2.2.2 Science, Technology, Engineering, and Technology Career Interest Scale (STEM-CIS)

STEM-CIS includes four subscales (science, technology, engineering, and mathematics) and 40 items (ten items in each subscale), using a five-point response range from 1 (strongly disagree) to 5 (strongly agree). The

Table 3 The Cronbach's ∝ coefficients and number of items in each subdimension of STEM_CIS

	Number of Items	Cronbach's Alpha	Adapted version of the scale (Koyunlu-Ünlü, Dökme & Ünlü, 2016)
Science	10	.862	.86
Mathematics	10	.888	.90
Technology	10	.895	.88
Engineering	10	.931	.94
Overall scale	40	.930	.93

scale was used to measure students' interest in STEM careers. Kier and colleagues developed the scale in 2014, and Koyunlu-Ünlü, Dökme, and Ünlü adapted the scale to Turkish in 2016.

Table 3 demonstrates the reliability coefficients in the adapted version of the scale and the coefficients calculated by the authors for the present study. The Turkish version of the scale reported the Cronbach's alpha for the subscales in the range of .86-.94 and the overall scale of .93 (Koyunlu-Ünlü, Dökme & Ünlü, 2016), indicating STEM-CIS is a highly reliable tool. The researchers calculated the Cronbach's alpha coefficients for the sampled students, and the results showed the coefficients ranged between .86-.93 for the subscales, and the reliability coefficient of the overall scale was .93. These coefficients assert that STEM-CIS would give reliable scores for the sampled students (Tabachnick & Fidel, 2019).

2.2.3 STEM Attitude Scale

The scale items, developed by İnam (2020), measured teachers' attitudes towards STEM education and included two subscales (STEM Activities and Lesson Planning) and 24 items. The original version of the scale had Cronbach's alpha coefficients of .916 for the overall scale, .953 for the STEM activities subscale, and .832 for the lesson planning subscale. The researchers calculated the reliability coefficients for the sampled teachers and found .92 for the overall scale, .95 for the STEM activities subscale, and .91 for the lesson planning subscale. These values indicate that the scale would give reliable results for teachers' attitudes toward STEM education (Tabachnick & Fidel, 2019).

2.2.4 Teacher Self-Efficacy Scale for STEM Practice

The scale was developed by Özdemir, Yaman & Vural (2018). Teachers were asked to rate their perceived efficacy in implementing STEM on a five-point scale ranging from 1 (never) to 5 (always). The tool is unidimensional and has 18 items measuring teachers' efficacy regarding STEM practice. The scale developers reported a Cronbach's s alpha of .97, and the researchers calculated the reliability coefficient as .96 for the sampled teachers. It is possible to note that the scale would give reliable results regarding teachers' perceived efficacy in STEM practice.

2.3 Procedure

After determining the instruments to collect data, the permissions were obtained from the scales' developers to use the scales in this study and from the Provincial Directorate for National Education to collect data from the middle school students and science and mathematics teachers in the province. Data was collected online considering the pandemic, and the school administrators were informed about the study, asking them to disseminate the survey link to science and mathematics teachers and students in their schools. Sampling aimed to ensure variety in data, selecting participants from predetermined strata (gender, parents' educational levels, family income for students and gender, content area, and teaching experience for teachers). All teachers and students received the survey link, and the participation was anonymous and voluntary. Participants were informed about the study, and informed consent was obtained from participants asking them to click "Yes" on the opening page of the survey if they wished to participate. The instruments took approximately 20 minutes to complete, and the procedure took 30 days. Twenty-one instruments from the student sample and six from the teacher sample were dropped from further analysis due to missing information and incorrect coding (selecting the same response for all items, inconsistent data, outliers, etc.). We considered minimizing the effect of random errors on our measurements to increase internal reliability. The return rate was 95.2% for students and 96.4% for teachers, indicating a higher value than the recommended return rate of 70%-80% (Büyüköztürk et al., 2011). The higher return rate level ensures making valid interpretations and generalizing the findings to the target population.

2.4 Data Analysis

Before data analysis, the normality of data was investigated based on the mean, median, and mode values, skewness and kurtosis values, and histogram graphics. Table 4 indicates the results of the normality of the data.

The normal distribution is symmetric; therefore, the mean, median, and mode values are close to each other in a normal distribution (Kalaycı, 2010). For example, Table 4 represents that the mean, median, and mode values of the STEM-CIS, the STEM Attitude Scale, and the Teacher Self-Efficacy Scale for STEM Practice are close to each other, and the skewness values ranged between -.456-.085, and kurtosis values ranged between -.930 and -.488. The literature includes different benchmarks for skewness and kurtosis values. For example, Tabachnick & Fidell (2019) proposed that skewness and kurtosis should be between -1.5 and +1.5, and George & Mallery (2003) asserted that the range of skewness and kurtosis should be -2.0 and +2.0. Therefore, the skewness and kurtosis of the scales used in

Table 4 The normality of data

	STEM-CIS	STEM Attitude Scale	Teacher Self-Efficacy Scale for STEM Practice
N	421	160	160
Mean	4.00	2.74	4.13
Median	4.05	2.80	4.15
Mode	4.50	3.00	5.00
Standard Deviation	.576	1.003	.565
Skewness	-.456	.085	-,.27
Kurtosis	-.425	-.488	-.930

Table 5 t-test results concerning the expected and observed means cores of the students' STEM career interests

	N	Observed mean score (i)	Sd	Expected mean score (j)	Mean difference (i-j)	t	p
Overall interest in STEM careers	421	4.00	.576	3.49	.51	18.183	.000
Science	421	3.94	.734	3.96	-.02	-.535	.593
Mathematics	421	4.12	.764	3.93	.19	5.211	.000
Technology	421	4.13	.755	3.79	.34	9.248	.000
Engineering	421	3.80	.950	3.54	.26	5.780	.000

this study met the benchmark criteria suggested for normal distribution. Therefore, we can say that the study's data approximated normal distribution, and it is possible to use parametric statistics for further analysis. The used statistics were as follows:

- One sample t-test was performed to compare students' mean scores in STEM-CIS to the expected mean score. In addition, relevant literature (Koyunlu-Ünlü & Dökme, 2020; Koyunlu-Ünlü, Dökme & Ünlü, 2016; Kier, Blanchard, Osborne & Albert, 2014) was investigated to determine the expected mean scores, which was 3.49 for the career interest, 3.96 for science subscale, 3.93 for mathematics subscale, 3.79 for technology subscale, and 3.54 for engineering subscale.
- Pearson Moments Product correlation coefficients were calculated to reveal the relationships between students' STEM career interests and teachers' STEM attitudes and self-efficacy beliefs.

Linear regression was performed to determine the predictive power of the teachers' STEM attitudes and self-efficacy beliefs on students' STEM career interests.

3. RESULT AND DISCUSSION

3.1 Students' Interests in STEM Careers

Firstly, we investigated the differences between the students' observed mean score of the interests and the expected mean score to describe the trends of students' STEM career interests. Figure 1 represents the observed mean and expected mean scores in the subscales.

Students' observed means scores differed from the expected mean scores except for the science subscale. The observed and expected mean scores were approximate in the science subscale. However, the observed mean scores were higher than expected in the mathematics, engineering, and technology subscales. Table 5 indicates whether the

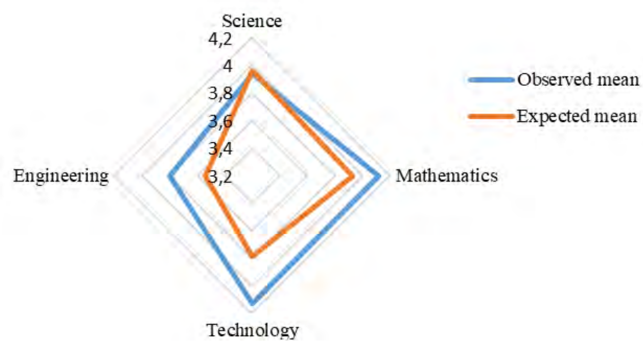

Figure 1 Students' observed mean scores and the expected mean scores in the STEM-CIS subscales

differences between the observed and expected mean scores are significant.

The observed mean score (M=4.00) in the overall interest was higher than the expected mean score (M=3.49), and the difference between the means was statistically significant (t_{421}=18.183; p<.05). The results revealed that participant students' interests in STEM careers were relatively high.

The differences between means were investigated in the subscales to reveal the source of the difference in the overall interests. The highest differences between the observed and expected means scores were in the technology (M_{i-j}=.34), engineering (M_{i-j}=.26), and mathematics subscales (M_{i-j}=.19), respectively. The differences were significant in favor of the observed mean scores ($t_{technology}$=9.248; $t_{engineering}$= 5.780; $t_{mathematics}$=5.211; p<.05). Unlike other subscales, the expected mean was higher than the observed mean in the science subscale (M_{i-j}=-.02), but the difference between the means was not statistically significant ($t_{science}$=-.535, p>.05). The results revealed that students had a high level of interest in

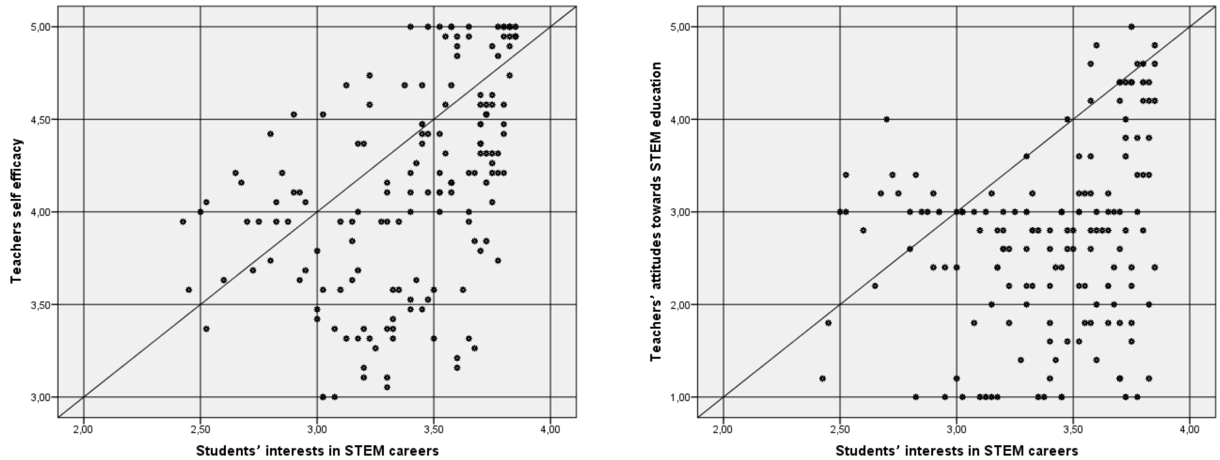

Figure 2 The relationships between students' interests and teachers' attitudes and self-efficacy beliefs

Table 6 Model summaries

Model	R	R²	Adjusted R²	Standard error of estimate
1	.250[a]	.062	.057	.347
2	.525[b]	.276	.267	.306

a. Predictors: (Constant) Teacher attitudes towards STEM education
b. Predictors: (Constant) Teacher attitudes towards STEM education and self-efficacy belief for STEM practice
c. Dependent variable: Students' interest in STEM careers

Table 7 Variance analyses

Model		Sum of the squares	Sd	Mean of the squares	F	p
1	Regression	1.270	1	1.270	10.524	.001
	Residual	19.060	158	.121		
	Total	20.330	159			
2	Regression	5.609	2	2.805	29.914	.000
	Residual	14.720	157	.094		
	Total	20.330	159			

technology, engineering, and mathematics careers, respectively. On the other hand, students' interest in science careers was low.

3.2 The Predictivity of Teachers' STEM Attitudes and Self-Efficacy Beliefs on Students' Interest in STEM Careers

The relationships between students' interests and teachers' attitudes and self-efficacy beliefs are presented in Figure 2.

Figure 2 indicates positive relationships between students' interests in STEM careers, teachers' attitudes towards STEM education, and self-efficacy beliefs for STEM practice. The relationship between students' interests and teachers' STEM attitudes was positive and weak ($r_{interest\text{-}attitude}$=.25, p<.01). Students' interests were moderately correlated with teachers' efficacy beliefs for STEM practice ($r_{interest\text{-}self\text{-}efficacy}$=.475, p<.01). The results revealed that students' interests in STEM careers were related to their teachers' STEM attitudes and self-efficacy beliefs.

The study's primary purpose is to reveal the extent to which teachers' attitudes towards and self-efficacy beliefs regarding STEM education predict their students' interest in STEM careers. Therefore, the regression analyses were performed to indicate teachers' attitudes and self-efficacy beliefs relative contributions to students' interests. Two models were developed for the present study. The first model investigates the predictivity power of the teacher attitudes on student interest, and the second model includes the contribution of teacher attitudes and self-efficacy beliefs to student interest. The results for the multiple regression analyses are given in Table 6, Table 7, and Table 8.

As seen in Table 6, the first model reveals a significant weak relationship between students' interest in STEM careers and teachers' attitudes toward STEM education (R=.250; R^2=.062; p<.01). Additionally, the second model indicates a significant moderate relationship between students' interests in STEM careers and teachers' attitudes and self-efficacy beliefs (R=.525; R^2=.276; p<.01). According to the first model, teacher attitudes explained 6.2% of the variance in students' interests. On the other hand, the second model indicates that teachers' attitudes

Table 8 The hierarchical multiple regression analyses with regards to predicting students' interests in STEM

Model		Unstandardized regression coefficients		Standardized regression coefficients	t	p
		B	Standard Error	Beta		
1	Constant	3.151	.080		39.363	.000
	Teacher attitudes towards STEM	.089	.027	.250	3.244	.001
2	Constant	1.965	.188		10.456	.000
	Teacher attitudes towards STEM	.080	.024	.225	3.305	.001
	Teacher self-efficacy for STEM practice	.293	.043	.463	6.803	.000

Dependent variable: Students' interests in STEM careers

towards and perceived efficacy beliefs regarding STEM education accounted for 27.6 of the variances in the outcome variable.

Table 7 reveals that the first and second models are statistically significant ($F_{Model\ 1}$=10.524, p<.05; $F_{Model\ 2}$=29.914, p<.01). Finally, Table 8 presents the multiple regression results of the factors influencing students' interest in STEM careers.

T-test results show that t values between students' interests and teachers' attitudes and efficacy beliefs in the first and second models were statistically significant (t_{Model1}-STEM attitudes = 3.244, p<.05; t_{Model2}-STEM self-efficacy=6.803, p<.05; t_{Model2}-STEM attitudes=3.305, p<.05). Given the standardized regression coefficients, it is seen that the coefficient indicating the effect of the teachers' self-efficacy beliefs for STEM practice on students' interest was higher than the teacher's STEM attitudes. Teacher efficacy beliefs for STEM practice have the highest beta (β=.463) and a moderate effect on students' interest, and teacher STEM attitudes have a modest effect (β=.225). Teachers' self-efficacy beliefs and attitudes were positive predictors of students' interests. The results show that teachers' efficacy for STEM practice especially has a crucial role in students' interests in STEM careers. The following equations indicate the relationships between the predictor and outcome variables.

(Model 1) *Students' interest in STEM careers*=3.151(cons.) +.089**Teacher STEM attitudes*

(Model 2) *Students' interest in STEM careers* = 1.965(cons.) + .293**Teacher STEM self-efficacy* + .080**Teacher STEM attitudes*

3.3 Discussion

This study investigated whether teachers' attitudes and self-efficacy beliefs predict students' interest in STEM careers. Firstly, the trends in students' interest in science, technology, engineering, and mathematics careers were investigated. It is seen that participant students' overall interest scores in STEM careers were relatively higher than expected. Therefore, it is possible to say that students are interested in STEM careers. The relatively high level of STEM career interest is promising since interest in STEM promotes students' decisions to pursue a STEM degree and career (Cheng, Antonenko, Ritzhaupt, & MacFadden, 2021; Christensen & Knezek, 2017). Therefore, it is possible to expect that participant students are more likely to have a STEM career in the future. The differences in STEM career interests in relation to background information are not within the context of the present study. A vast majority of research considers further information about the extent to which background variables differentiated students' STEM career interests (Bahar & Adıgüzel, 2016; Cerinsek, Hribar, Glodez & Dolinsek, 2013; Chachashvili-Bolotin, Milner-Bolotin & Lissitsa, 2016; Christensen & Knezek, 2017; Koyunlu-Ünlü & Dökme, 2020). The present study also investigated the difference between the observed and expected mean scores in STEM fields and revealed relatively high interest in technology, engineering, and mathematics careers. However, students were less interested in science careers. The less interest in science careers might stem from a stereotype that views science as a challenging subject and believes only a few high-ability students can master it (Crovrther & Bonnstetter, 1997).

There is evidence regarding students reporting the effect of their teachers on their STEM career interests (Bahar & Adıgüzel, 2016; Cerinsek, Hribar, Glodez & Dolinsek, 2013; Chachashvili-Bolotin, Milner-Bolotin & Lissitsa, 2016; Christensen, Knezek, & Tyler-Wood, 2015). Cheng, Antonenko, Ritzhaupt, & MacFadden, (2021) examined teachers' 3D printing and STEM integration levels and reported that only STEM integration levels predicted student interest. However, research is still needed to investigate the relationship between teacher-reported and student-reported data to predict whether teacher-related variables, such as efficacy and attitudes, predict students' STEM career interests. The present study primarily sought to reveal the predictivity of mathematics and science teachers' STEM attitudes and self-efficacy beliefs on their students' interests in STEM careers. The regression results showed positive moderate and modest relationships between students' interest in STEM careers and teachers' STEM attitudes and self-efficacy beliefs, indicating that teacher attitudes and perceived efficacy were significant predictors of students' interest in STEM careers. These results support the evidence from student reports indicating teachers influence their interest in STEM careers. Furthermore, the relationship between teachers' self-efficacy and students' interests was stronger than between teacher attitudes and student interests, indicating that increasing teacher efficacy beliefs would advance student interests more than teacher attitudes did. These results confirm the strong association between teacher efficacy and student achievement and motivation (Işıksal-Bostan, 2016; Kim & Seo, 2018; Sarac & Tutak, 2017) and students' classroom engagement (Kundu, Bej, & Dey, 2021).

Regression analysis was performed; teacher attitudes and self-efficacy beliefs were predictor variables, and students' interests in STEM careers were the outcome variable. Two models were established in the present study. The first model included teacher attitudes, explaining a 6.2% variance in students' interest, and the second had teacher attitudes and self-efficacy beliefs, explaining 27.6% of the variance. Teachers' STEM attitudes and self-efficacy beliefs accounted for one-quarter of the variance in STEM career interest, which is a relatively high percentage, indicating the importance of teacher-related variables (Bahar & Adıgüzel, 2016; Chachashvili-Bolotin, Milner-Bolotin & Lissitsa, 2016; Regan & DeWitt, 2015; Sjaastad, 2012). Teacher attitudes and self-efficacy beliefs are connected (Pajares, 1992) and form a theoretical basis for teachers' instructional behaviors (Thibaut, Knipprath, Dehaene, & Depaepe, 2018). Teachers' STEM attitudes and self-efficacy beliefs, the cognitive and affective domains of teachers' motivational orientations, might provide an active learning environment in which students find the opportunity to explore their STEM ability and proficiency, which would increase their STEM career interest (Sjaastad, 2012).

It is also seen that teacher attitudes explained 6.25% of the variance in students' STEM career interests, and teacher efficacy beliefs accounted for 22.6% of the variance. Teachers' self-efficacy beliefs for STEM practice had a more significant impact on students' interest in STEM careers than teachers' attitudes towards STEM education had. Students whose teachers perceived their efficacy for STEM practice as sufficient were more inclined to STEM careers. Besides, evidence indicates the relationship between teacher self-efficacy and students' mathematics performance (Goddard, Hoy, & Hoy, 2000) and science performance (Mohamadi & Asadzadeh, 2012). Strong self-efficacy strongly predicts teachers' level of STEM engagement (Geng, Jang, & Chai, 2019) and is closely related to positive attitudes (Dong et al., 2019). Therefore, teachers should have strong efficacy beliefs for planning and implementing STEM activities in and out of school since engaging students with STEM activities increases their students' interests in STEM careers (Margot & Kettler, 2019).

CONCLUSION

It is worth reporting that the present study provides the following implications: developing students' interest in science careers and promoting teachers' attitudes and self-efficacy beliefs with a holistic perspective. The participant students had a relatively lower interest in science careers. This finding needed to be interpreted with caution because the negative attitudes regarding science comprise part of the problem with increasing STEM achievement (Paulson, 2009). Therefore, authentic and out-of-school science activities might be constructed to develop students' interest in science careers (Tasdemir, Kartal & Özdemir, 2014). After-school programs also promote females' perceptions of science careers (Tyler-Wood, Ellison, Lim & Periathiruvadi, 2012).

Additionally, parental support and academic expectations should be considered influential in promoting their children's science learning and interest in science careers, and parents should be acknowledged for science careers (Halim, Abd Rahman, Zamri & Mohtar, 2018). Considering the impact of the cognitive and affective domains of teachers' motivational orientations, teachers and researchers should seek ways to improve teacher attitudes and self-efficacy beliefs regarding STEM. Teachers need to see STEM activities they could use in their classrooms (Jamil, Linder, & Stegelin, 2018). Teachers with prior experience and training in STEM education experienced intrinsic challenges and barriers lower than those who did not (Dong, Wang, Yang & Kurup, 2020). Teachers' needs-based professional development programs help teachers meet the demands and goals of STEM education (Al Salami, Makela & de Miranda, 2017; Jamil, Linder, & Stegelin, 2018).

Teachers should experience the differences in students' behaviors and learning to which the new approaches they adopted led since their attitudes and beliefs change when they see the effect of a new method or approach on students learning (Al Salami, Makela & de Miranda, 2017). Additionally, teachers should experience collaborating with peers and STEM experts. For example, Knowles, Kelley & Holland (2018) found that staying in touch with STEM experts when planning STEM lessons, learning more about the STEM career pathways, and generating their integrated STEM lessons increased teachers' STEM career awareness.

RECOMMENDATIONS

Considering the implications of the present study, we suggest that further research should include detailed qualitative or mixed-method research designs to understand better the underlying factors of lower interest in science careers and the stronger effect of teacher-efficacy beliefs than attitudes. In addition, interviews and observations would serve as a valuable avenue to comprehend why teacher efficacy beliefs have a more noticeable impact on students' interest in STEM careers than their attitudes.

LIMITATIONS

This study is limited to self-reported measures, remaining the underlying reasons for the relationships between teacher attitudes and self-efficacy beliefs and student interests unclear. Further work needs to be carried out to provide detailed information about the relationships between the constructs of interest in the present study, using in-depth interviews and observations. The explained variance in students' STEM career interest is 26.2%, leaving 73.8% of the variance unexplained. The environmental and other social factors should be included in further models to account for more variance.

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