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# Investigation of STEM fields motivation among female students in science education colleges

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## Abstract

**Background:** The expectancy-value theory that constitutes the theoretical background of this study on motivation provides a strong framework for cognitive development, as it includes most of the beliefs, values, and goal variables found in various theories on motivation. Besides, this theory focuses directly on how different socializers such as parents and teachers influence the students' development of motivation. Strong motivation of teachers towards STEM fields is important both in terms of performing STEM activities in their own classrooms and motivating their students to STEM fields.

**The context and purpose of the study:** Our current research examines the motivation of female students in science education college towards their STEM fields according to certain demographic properties. Three-quarters of the students enrolled in science education colleges in Turkey are women who are under-represented in STEM fields. Determining the motivation of female science education college students towards STEM fields can be considered a long-term, sustainable, and pervasive effect, as they are the potential STEM educators of the future.

**Results:** As a result of the study, it was determined that the motivation of female science education college (university) students towards STEM fields did not differ according to grade level, type of high school they graduated from, and family income. However, motivation towards STEM fields did differ according to variables of "having received STEM training", "having participated in STEM activities", "having (or not having) a role model working in a STEM field" and, "father education-level".

**Conclusions:** The results obtained from this study are valuable for the design of possible intervention studies in the future. For example, designing role model interventions, incorporating STEM training into education college programs, and organizing more STEM activities within education college programs are considered to be important steps to increase the motivation of female science education college students. Increasing the motivation of prospective science teacher candidates towards STEM fields with various interventions has indirect importance for them to motivate their students to consider STEM fields in their future professional lives.

**Keywords:** Science education, STEM, Female and STEM, Motivation, Expectancy-Value Theory, Descriptive survey model

## Introduction

STEM fields are of vital importance in determining the prosperity and success of a society in sourcing and using natural resources and expanding the boundaries of innovation, supporting labor force participation in the rapidly developing technological world, and global competition

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(Breiner et al., 2012; Kijima et al., 2021; Urban & Favlo, 2016). However, as a pedagogical approach, STEM education has started to appear in literature as an extension of the inquiry learning strategy and it has been extensively researched (Bybee, 2013; Cedillo, 2018; Conradty & Bogner, 2019; Deák et al., 2021; Sergis et al., 2019). Before the turn of the last century, the knowledge boom in natural sciences led to inquiry learning as a learning approach in science education that centers around learning processes rather than science content. In other words, there has been a shift from instructional approaches rooted in behavioral theories to first cognitive and then constructivist teaching approaches and models (Cooper, 1993). One of the most important contributions of inquiry-based approaches in science education has been revealing that scientific thinking skills can be taught to students at an early age and can be developed over time (Lu et al., 2021; Memiş & Akkaş, 2020; Zimmerman, 2000). Instructional models arising from these approaches, such as inquiry-based learning, problem-based learning and project-based learning have long been implemented in science teaching (Barrow, 2006; Hallinger, 2020; Hmelo-Silver, 2004; Krajcik & Blumenfeld, 2005). Recently, the learning by inquiry approach has evolved into STEM education by including some innovations (Cedillo, 2018; Grangeat et al., 2021). For example, the motto of ‘Let us teach students the process of knowledge discovery rather than knowledge itself’ in learning by inquiry has turned into the motto of ‘knowing is not enough, we must apply’ in STEM education. As the motto suggests, knowledge is just the beginning of a quality learning experience. If we want to learn, we must apply the knowledge we have. In STEM education, knowledge in science has been integrated by including mathematics and technology, and the pinnacle of cognition has been represented by an engineering product (National Science Board [NSB], 2008). STEM education at all grade levels from pre-school to post-doctoral and in both formal and informal classrooms (Gonzalez & Kuenzi, 2012) has come into prominence as an innovative and interdisciplinary education approach that educates individuals worldwide in a way that can meet the expectations of the twenty-first century.

STEM education is seen as a pioneer of economic growth and innovation, but despite the progress made in the last 20 years, studies have shown that students’ interest in STEM fields has decreased and they are moving away from these fields (Habig & Gupta, 2021; Romine & Sadler, 2016; Rozek et al., 2017; Wang, 2013). Similarly, in many reports prepared in Turkey and other countries, students—especially female students—have inadequate tendencies to continue their STEM programs and to pursue their careers in this field (Akgündüz et al., 2015;

National Science Foundation [NSF], 2011). Based on the results of research conducted by various organizations, women’s education in STEM fields and their orientation towards STEM professions are likened to the “leaky pipeline” metaphor (Almukhambetova et al., 2021; Grogan, 2019). According to this metaphor, women’s participation in higher education increases, while their position in higher academic positions decreases. Additionally, the UNESCO (2019) report found that women are not sufficiently represented in the field of science in the world and that women throughout the world make up 29.2% of researchers. The importance of motivation is emphasized in studies focused on possible causes of inadequate tendencies, especially of female students, to continue their STEM programs and pursue their careers in STEM fields (Almukhambetova et al., 2021; Eccles-Parsons et al., 1983; Leaper & Starr, 2019; Nugent et al., 2015; Rosenzweig & Wigfield, 2016; Rozek et al., 2017). Motivation not only determines the success or failure of an individual in completing a complex task but also reflects the person’s desire to reach a goal (Fadzli et al., 2020). According to Leaper and Starr (2019), gender inequality in STEM is rooted in fundamental differences in motivation rather than academic achievement. It is necessary to inspire all students of both genders to learn STEM and motivate many of them to pursue their STEM careers (PCAST, 2010). In fact, as Simpkins et al. (2006) highlighted, all resources should be mobilized to help motivate students in their academic preferences for career choice in STEM fields.

Although there are many factors that will support the motivation of students to turn to STEM and continue with determination in these fields, the role of the teacher, who will help create social motives, is seen as a critical factor (Jungert et al., 2020; Nugent et al., 2015). Understanding how this factor affects students’ motives and motivation will depend on many variables, such as teacher’s characteristics, beliefs, and teaching practices (Wentzel, 2009). Bell (2016) emphasized that the motivational STEM practices conducted by the teacher in the classroom are related to the teachers’ perception of and motivation towards STEM. McInerney (2008), on the other hand, stated that motivational supports students receive from their teachers affects their next steps in education as well as their career goals. According to Margot and Kettler (2019), teachers’ efficacy beliefs and the value they place on STEM education influence their willingness to participate and apply in the STEM curriculum. Since the teachers who think that they are competent in the field of STEM and who have a high perception value towards STEM will have a higher motivation for success than other teachers, they are more likely to perform STEM practices in their classrooms, motivate their

students about STEM, and provide guidance and support related to STEM fields.

Given the complex dynamics at play in the abovementioned contexts, conducting studies that investigate the motivation of female science education college students towards STEM fields can be considered a long-term, sustainable, and pervasive effect, as they are the potential STEM educators of the future. Therefore, the study determines the motivation of women science education college students towards STEM fields according to certain demographic properties in the theoretical framework of the expectancy-value theory by Eccles-Parsons et al. (1983). As expectancy-value theory associates students' motivational differences with the socialization factor (Wang & Degol, 2013), demographic properties were determined in this study according to the students' contextual differences in the socialization factors such as the type of school graduated, educational and socioeconomic status of parents, and opportunities of having received special STEM training or having participated in STEM activities. Bieri Buschor et al. (2014) stated that "young women who describe themselves as being more family-oriented and less job-oriented show a more negative attitude toward jobs in the STEM field than women who place a high importance on a professional career (Hanover & Kessels, 2004)". Therefore, it was considered that another factor that could trigger motivational differences could be 'having (or not having) a role model working in a STEM field', especially since the study comprised a female participant group.

The main research question in this study is as follows: Is there a significant difference in motivation scores towards STEM fields of female students in science education colleges according to certain demographic variables (grade levels, type of high school graduated, education level of parents, and income level of the family, having received STEM training, having participated in STEM activities and, having a role model in a STEM field)?

### Theoretical framework

Although there are many theories (goals, self-determination, intelligence, choice, expectation-value, etc.) in the literature on motivation, which has a wide theoretical framework (Irvine, 2018), the expectancy-value theory of Eccles-Parsons et al. (1983) has guided most of the work on cognitive motivation over the past 30 years (Eccles, 2011; Eccles-Parsons et al., 1983; Wigfield, 1994; Wigfield & Eccles, 2000; Wigfield & Gladstone, 2019). This theory provides a strong framework for developing achievement, as it includes most of the beliefs, values, and goal variables found in various theories in the field, focuses directly on how different socializers such as parents and teachers influence the development of achievement motivation,

and broad cultural influences are an important part of the model (Wigfield et al., 2015).

Eccles-Parsons et al. (1983) assumed that in their expectation-value theory, students' motivation to perform their achievement tasks (e.g., doing homework or trying to develop a skill, choosing to pursue certain activities that help develop skills, using strategies to develop skills) was determined by their expectations for success in a task and to what extent they valued it (Rosenzweig et al., 2019). Additionally, it was argued that in theory individuals' interpretations of their previous performance and perceptions of the attitudes and expectations of socializers (especially teachers and parents) influence beliefs (expectations and values) related to achievement (Battle & Wigfield, 2003). "Expectation for success," one of the components of the theory, empirically overlaps with the individual's self-efficacy belief in the relevant field (Appianing & Van Eck, 2018; Irvine, 2018) and according to the answer to "Can I do the task?" question, success affects motivation. Generally, individuals who respond positively to this question try harder, go on longer, perform better, and are motivated to choose more challenging tasks (Wigfield et al., 2015). According to Bandura (1997), individuals' belief that they can perform a certain task or activity is an important descriptor of activity choice, willingness to make an effort, and perseverance.

The other component of the theory is "subjective task value," which refers to the importance or meaning attributed to the task while performing the task (Putwain et al., 2019) and according to the answer to "Do I want to do the task?" question, success affects motivation. As stated by Barron and Hulleman (2015), individuals who believe that they value something are more likely to engage in this behavior. Therefore, the values of individuals have both motivational and behavioral consequences (Eccles & Wigfield, 1995). Students who value different academic activities are likely to study harder and more effectively, continuing to pursue the goals they have set even if they encounter difficulties (Wigfield & Eccles, 2002). Eccles-Parsons et al. (1983) stated that subjective task value of individuals was positively affected by three components: "attainment value," "intrinsic value," and "utility value," and negatively affected by "cost value" (Eccles, 2005; Rosenzweig et al., 2019; Wigfield & Gladstone, 2019). "Attainment value" refers to the relevance of the task to the individual's self-identity, "intrinsic value" refers to the individual's enjoyment of performing a task or activity, or the individual's subjective interest in the subject, and "utility value" refers to the individual's suitability for their current or future goals. The "cost value," which negatively affects the component, is related to what must be sacrificed to participate in a task (Eccles, 2005; Wigfield,

1994). Based on these definitions, it is possible that individuals who think that STEM activities are suitable for them and find it useful and enjoyable tend to be willing to participate in the activities, while individuals who think that they will get a reaction from socializers, experience failure, or the activity is not worth the time and effort they spend show a tendency to avoid these activities.

In generally the expectation-value theory, which explains the motivation for success in education from a broad perspective, students' success expectations and subjective task values are strong predictors of their achievement-related behavior and both academic and career choices (Wigfield et al., 2015). According to Hidi and Renninger (2006), increasing students' value perceptions and expectations can lead to the development of an interest in a field, including interest in a career. In this regard, students' expectations for success and perceived value are two important variables in their orientation to STEM fields, making efforts and ensuring continuity in these areas.

## Methods

This is a quantitative study employing a descriptive survey model. The survey model describes some aspects and characteristics of the population (such as abilities, ideas, attitudes, beliefs, and knowledge) with the help of data obtained from a sample selected from the population (Frankel & Wallen, 2009).

## Study group

In this study, data were collected using a convenience sampling method. In convenience sampling, which is an improbable sampling method, data are collected from the members of the population who are easily reached or willing to participate in accordance with the purpose of the research (Dörnyei, 2007). An online questionnaire consisting of two parts was sent to approximately 2000 female students (YOK Atlas, 2021) studying in the 3rd and 4th years of science education colleges in 21 different universities in Turkey. Ultimately, 309 female students completed the questionnaire and their demographic characteristics are shown in Table 1.

## Data collection tools

Written instructions were included at the beginning of the data collection tool kit used in this study. On the printed instruction sheet, the purpose of the research was explained, the definition of STEM education was given, and the fact that participation was voluntary was mentioned. Furthermore, the instructions stated that the information obtained would only be used in research. Finally, the instructions provided information on how to

**Table 1** Demographic distribution of the students participating in the survey

Demographic Information	Frequency
Grade levels	
3. Grade	123
4. Grade	186
The type of high school graduated	
Anatolian High School	214
Others (Science-Vocational-Technical-Religious High School)	95
Family's income level	
2500 · and below	79
2501 —4000 ·	113
4001 · and above	117
Mother's educational level	
Primary School	160
Middle School	59
High School	61
University	29
Father's educational level	
Primary School	108
Middle School	66
High School	77
University	58
Having received STEM training	
Yes	100
No	209
Having participated in STEM activities	
I joined	76
I did not	233
Having a role model working in a STEM field	
Working	81
Not working	228

fill in the survey (our data collection tool), which will be described next.

The data collection tool consists of two parts. The first part of the data collection tool includes demographic characteristics of the participants which are used as independent variables such as grade levels, the type of high school attended, education level of parents, income level of the family, having participated in STEM activities, having received STEM training, and having a role model working in a STEM field.

The frequency distributions related to answers to the questions in this section are shown in Table 1. In this part of the form, the answers are presented as a list of options that participants can either tick or leave blank. However, participants were then asked to make additional explanations for 'having participated in STEM activities', 'having received STEM training' and 'having a role model



working in a STEM field'. The following explanations regarding these three variables in the form were given to the participants as footnotes: 'Having received STEM training (certified)' includes elective courses taken in college education, STEM certificate programs obtained from private institutions, STEM camps within the scope of projects supported by the Scientific Research and Technological Research Council of Turkey. 'Having participated in STEM activities (uncertified)' includes just one or a few activities related to STEM other than certification purposes, such as conferences or seminars. 'Having a role model working in a STEM field' includes the identification of a role model working in STEM fields, if any, and an explanation of why such a person is considered to be a role model.

The second part of the data collection tool includes "Value—Expectancy STEM Assessment Scale" (VESAS) to measure motivation towards STEM fields, which is the dependent variable of the research. VESAS was developed by Appianing and Van Eck (2018) to determine the motivation of female university students towards STEM on the basis of expectancy-value theory. This scale has a two-factor structure, based on expectancy-value theory, in a 5-point Likert type, consisting of 15 items with loadings ranging from 0.51 to 0.91 and 7 of which are reversed. The Cronbach Alpha value of the factor "expectations for success in STEM careers" is 0.89, and the Cronbach Alpha value of the "perceived value of STEM fields" factor is 0.90. This scale was adapted to Turkish by Açiksöz et al., (2020) to measure the towards STEM fields motivations of teacher candidates. As a result of the first confirmatory factor analysis conducted on the version of the scale adapted to Turkish by Açiksöz et al., (2020), one item was removed from the scale by taking expert opinions. In the second confirmatory factor analysis, it was determined that all goodness-of-fit index showed good fit ( $\chi^2/df$ -2.1, RMSEA-0.75, CFI-0.97, GFI-0.90, AGFI-0.85, SRMR-0.058, IFI-0.97, NFI-0.94, NNFI-0.96). In the reliability analyzes of the scale whose construct validity was verified, the internal consistency coefficient of the "perceived value of STEM fields" factor was calculated as 0.82, the internal consistency coefficient of the "expectations for success in STEM careers" factor was calculated as 0.82, and the internal consistency of the whole scale was calculated as 0.87 (Açiksöz et al., 2020).

#### Data collection procedures

Since STEM is a new educational approach for Turkey, it was decided to apply to the 3rd and 4th year students who are assumed to have STEM awareness. Participants were determined from universities that researchers could easily reach, and ethics committee approval was obtained. Data were collected via the online Google form, which

contains the instructions on how to fill it out. A Google form link was sent to the academicians working at the selected universities and it was requested to be delivered to the students. The data collection process of the research which was conducted in the spring term of the 2020–2021 academic year, took approximately 4 weeks.

#### Data analysis

The analysis of the online data obtained in the research was carried out using the IBM SPSS Statistic v.22 Package program. There are no missing data since the online scale is set so that it cannot be completed when there are missing data. First, the reverse items in the scale were coded straight in the SPSS program, and then Kurtosis and Skewness values were examined to determine the use of parametric or non-parametric tests in the analysis of the obtained data.

According to Tabachnick and Fidell (2013), Kurtosis and Skewness values in the range of  $\pm 1.5$  in the normality test indicate that the variables have a normal distribution. In two different dimensions of the scale, the data in the variable categories were not normally distributed so non-parametric tests were used in the data analysis performed. Mann Whitney *U* Test was used to analyze whether the scores of motivation towards STEM fields differ according to variables of grade level, the type of high school graduated, having received STEM training, having participated in STEM activities, and having a role model working in a STEM field. Kruskal–Wallis Test was used in the analysis of whether the scores of motivation towards STEM fields differ according to, family income level and parental education level. The interpretation of the analysis results was based on the 0.05 significance level.

#### Result

##### Grade and VESAS scores

Table 2 shows the Mann Whitney *U*-test results of 3rd and 4th year female participants' motivation scores towards STEM fields.

According to Table 2, there is no statistically significant difference between the total motivation scores of 3rd and 4th year participants towards their STEM fields ( $p > 0.05$ ). Additionally, scores for the sub-dimensions of "perceived value of STEM fields" and "expectations for success in STEM careers" did not differ according to the grade level ( $p > 0.05$ ).

##### Graduated high school type and VESAS scores

Table 3 shows the Mann Whitney *U* test results of female participants' motivation scores towards STEM fields according to the type of high school graduated.

According to Table 3, there is no statistically significant difference between the total motivation scores of participants graduated from “others” and “Anatolian High School” towards their STEM fields ( $p > 0.05$ ). Scores for the sub-dimensions of “perceived value of STEM fields” and “expectations for success in STEM careers” did not differ according to type of high school graduated ( $p > 0.05$ ).

#### Family income level and VESAS scores

Table 4, shows the results of Kruskal–Wallis test, conducted to examine whether there is a significant difference between students’ towards STEM fields motivation scores and family income level.

According to Table 4, there is seen a statistically significant difference between participants’ motivation scores and their family income level. However, to examine the potential source of the difference, the Man Whitney  $U$

test was performed on the pairwise combinations of the groups. The following results emerged from this test analysis:

- There is no statistically significant difference between the scores of “total-VESAS”, “perceived value of STEM fields”, “the expectations for success in STEM careers” of participants with low and high family income ( $p > 0.05$ ).
- There is no statistically significant difference between the participants’ scores of “perceived value of STEM fields” and their family income levels ( $p > 0.05$ ).
- There is a significant difference between the medium- and high-income participants’ total scores towards STEM motivation in favor of the high-income groups ( $p < 0.05$ ).
- There is a significant difference between the medium- and high-income participants’ scores towards “the

**Table 2** Results of Mann Whitney  $U$  test for participants’ STEM motivation scores according to grade

Groups	Perceived value of STEM fields	Expectations for success in STEM careers	Total-VESAS
	Median (Min. – Max.)	Median (Min. – Max.)	Mediyan (Min. – Max.)
3.Grade	28 (19 – 35)	26 (16 – 35)	54 (35 – 75)
4.Grade	29 (16 – 35)	27 (13 – 35)	55 (37 – 70)
Test statistics	$z = -0.057$	$z = -1.729$	$z = -0.724$
$p$	0.955	0.084	0.469

**Table 3** Mann Whitney  $U$  test results for participants’ STEM motivation scores according to high school type graduated

Groups	Perceived value of STEM fields	Expectations for success in STEM careers	Total-VESAS
	Median (Min. – Max.)	Median (Min. – Max.)	Median (Min. – Max.)
Others	28 (21 – 35)	26 (13 – 35)	55 (37 – 68)
Anatolian High School	29 (16 – 35)	26.5 (14 – 35)	55 (35 – 70)
Test statistics	$z = -0.038$	$z = -0.156$	$z = -0.724$
$p$	0.970	0.876	0.833

**Table 4** The results of Kruskal – Wallis test for participants’ STEM motivation scores according to family income level

Groups	Perceived value of STEM fields	Expectations for success in STEM careers	Total-VESAS
	Median (Min. – Max.)	Median (Min. – Max.)	Median (Min. – Max.)
2500 · and below (A)	30 (21 – 35)	26 (13 – 35)	55 (40 – 70)
2501–4500 · (B)	28 (16 – 35)	26 (16 – 35)	54 (37 – 70)
4501–6000 · (C)	29 (19 – 35)	27 (14 – 34)	56 (35 – 69)
Test statistics	$\chi^2 = 4.724$	$\chi^2 = 14.69$	$\chi^2 = 10.20$
$p$	0.94	<b>0.001</b>	<b>0.006</b>
Significant difference		C > B	C > B

expectations for success in STEM careers sub-dimension” in favor of the high-income groups ( $p < 0.05$ ).

#### Mother educational level and the VESAS scores

The results of Kruskal – Wallis test on whether there is a significant difference between female participants’ motivation scores towards STEM fields and their mothers’ education level are shown in Table 5.

According to Table 5, no significant difference is found between the participants’ maternal education levels and their scores of “total-VESAS”, “expectations for success in STEM careers” ( $p > 0.05$ ). However, there is a statistically significant difference between the participants’ scores of “perceived value of STEM fields” and their maternal education levels ( $p < 0.05$ ). This difference shows that the “perceived value of STEM fields” scores of the students whose mothers are secondary school graduates are higher than those of the participants whose mothers are high school graduates.

#### Father Educational Level and the VESAS Scores

The results of Kruskal – Wallis test on whether there is a significant difference between female participants’ motivation scores towards STEM fields and their fathers’ education level are shown in Table 5.

According to Table 6, there is no statistically significant difference between the participants’ scores of “perceived value of STEM fields” and their fathers’ educational levels ( $p > 0.05$ ). However, there is a statistically significant difference between participants’ scores of “total VESAS”, “expectations for success in STEM careers” and their fathers’ educational levels. To examine the potential source of the difference, the Man Whitney  $U$  test was performed on the pairwise combinations of the groups. The following results emerged from this test analysis:

- There is a significant difference between the participants whose fathers graduated from middle school and high school according to the scores of “expectations for success in STEM careers” ( $p < 0.05$ ) in favor of the participants with fathers graduated from high school.
- There is a significant difference between the participants whose fathers graduated from primary school and high school according to the scores of “total VESAS” ( $p < 0.05$ ) in favor of the participants with fathers graduated from high school.
- There is a significant difference between the participants whose fathers graduated from middle school and high school according to the scores of “total

**Table 5** The results of Kruskal – Wallis test for participants’ STEM motivation scores according to their mothers’ educational levels

Groups	Perceived value of STEM fields	Expectations for success in STEM careers	Total-VESAS
	Median (Min. – Max.)	Median (Min. – Max.)	Median (Min. – Max.)
Primary school (A)	28 (21 – 35)	27 (13 – 35)	55 (40 – 70)
Middle School (B)	29 (16 – 35)	27 (19 – 35)	56 (41 – 70)
High school (C)	27 (19 – 35)	25 (14 – 33)	53 (35 – 65)
University (D)	29 (21 – 34)	27 (14 – 32)	55 (37 – 66)
Test statistics	$\chi^2 = 13.07$	$\chi^2 = 3.95$	$\chi^2 = 5.07$
$p$	<b>0.004</b>	0.266	0.166
Significant difference	B > C		

**Table 6** The results of Kruskal – Wallis test for participants’ STEM motivation scores according to their fathers’ educational levels

Groups	Perceived value of STEM fields	Expectations for success in STEM careers	Total-VESAS
	Median (Min. – Max.)	Median (Min. – Max.)	Median (Min. – Max.)
Primary school (A)	28 (22 – 35)	26 (13 – 35)	54 (40 – 70)
Middle School (B)	28 (21 – 35)	26 (21 – 35)	53 (44 – 70)
High school (C)	29 (16 – 35)	27 (16 – 34)	56 (35 – 67)
University (D)	29 (21 – 35)	28 (14 – 34)	56 (37 – 69)
Test statistics	$\chi^2 = 3.45$	$\chi^2 = 10.85$	$\chi^2 = 7.92$
$p$	0.327	<b>0.013</b>	<b>0.048</b>
Significant difference		B < C	A < C, B < C

VESAS” ( $p < 0.05$ ) in favor of the participants with fathers graduated from high school.

#### The having received STEM training and VESAS scores

Table 7 shows the Mann Whitney  $U$  test results on whether there is a significant difference between participants’ motivation scores towards STEM fields and the variable of ‘having received STEM training’.

According to Table 7, there is a significant difference between the scores of “total VESAS”, “perceived value of STEM fields”, “expectations for success in STEM careers” of the participants who participated in STEM education and did not ( $p < 0.05$ ). The all scores of the participants who participated in STEM training were higher than those who did not.

#### Having participated in STEM activities and VESAS scores

Table 8 shows the Mann Whitney  $U$  test results on whether there is a significant difference between the participants’ motivation scores towards STEM fields and the variable of ‘having participated in STEM activities’.

According to Table 8, there is a significant difference between the scores of “total VESAS”, “perceived value of STEM fields”, “expectations for success in STEM careers” of participants who participated in STEM activities and did not ( $p < 0.05$ ). The all scores of the participants who participated in STEM activities are higher than those who did not.

#### Having a role model working in a STEM field and VESAS scores

Table 9 shows the Mann Whitney  $U$  test results on whether there is a significant difference between the participants’ motivation scores towards STEM fields and the

**Table 7** The results of Mann Whitney  $U$  test for participants’ STEM motivation scores according to the variable of “Having received STEM training”

Groups	Perceived value of STEM fields	Expectations for success in STEM careers	Total-VESAS
	Median (Min. – Max.)	Median (Min. – Max.)	Median (Min. – Max.)
Yes	29.5 (16–35)	28 (19–35)	57 (41–70)
No	28 (19–35)	26 (13–35)	54 (35–70)
Test statistics	$z = -2.42$	$z = -3.25$	$z = -3.15$
$p$	<b>0.015</b>	<b>0.001</b>	<b>0.002</b>

**Table 8** The results of Mann Whitney  $U$  test for participants’ STEM motivation scores according to the variable of ‘having participated in STEM activities’

Groups	Perceived value of STEM fields	Expectations for success in STEM careers	Total-VESAS
	Median (Min. – Max.)	Median (Min. – Max.)	Median (Min. – Max.)
I joined	29.5 (16–35)	27 (21–35)	57 (41–70)
I did not	28 (19–35)	26 (13–35)	54 (35–70)
Test statistics	$z = -2.73$	$z = -3.27$	$z = -3.40$
$p$	<b>0.006</b>	<b>0.001</b>	<b>0.001</b>

**Table 9** The results of Mann Whitney  $U$  test for participants’ STEM motivation scores according to the variable of ‘having a role model working in a STEM field’

Groups	Perceived value of STEM fields	Expectations for success in STEM careers	Total-VESAS
	Median (Min. – Max.)	Median (Min. – Max.)	Median (Min. – Max.)
Working	30 (21–35)	28 (20–35)	58 (44–70)
Not working	28 (16–35)	26 (13–35)	54 (35–70)
Test statistics	$z = -3.51$	$z = -3.99$	$z = -4.36$
$p$	<b>0.000</b>	<b>0.000</b>	<b>0.001</b>



variable of 'having a role model working in the STEM field'.

According to Table 9, there is a significant difference between the scores of "total VESAS", "perceived value of STEM fields", "expectations for success in STEM careers" of participants who have a role model working in the STEM field and do not ( $p < 0.05$ ). The all scores of the participants who have a role model working in the STEM field are higher than those who do not.

## Discussion

Strong motivation of teachers towards STEM fields is important both in terms of performing STEM activities in their own classrooms and motivating their students to become more interested STEM fields. It is possible to see examples of this in the literature. For example, it has been observed that teachers included in an engineering-enriched education curriculum are successful in engineering education and promote their students in engineering careers (Autenrieth et al., 2017). Also, as a result of a professional development program for physics teachers on the integration of engineering into physics classrooms, it was revealed that teachers who participated were motivated to integrate engineering into their classrooms (Dare et al., 2014). In the current study, the factors affecting the motivation of female science education college students towards the STEM field were investigated because this participant group can provide insights about future STEM educators. The findings show that science education college students who are significantly more motivated towards STEM fields participated in the STEM training (certified), STEM activity (uncertified) or have someone he/she takes as a role model has a profession in STEM fields. These three effects will be clarified here.

The STEM training in which the highly motivated students participate are grouped under three headings: *STEM camps* within the scope of projects supported by The Scientific and Technological Research Council of Turkey, *STEM-related elective courses* taken in college education, and *certificate programs* obtained from private institutions for a fee. The most common feature of these three educational activities is that they focus on applied STEM education. *STEM camps* are usually held in hotels in the summer and these camps reveal the potential to increase student motivation levels through well-designed STEM experiences (English, 2017). Science education college students are trained from 9 a.m. to 5 p.m. for approximately 2 weeks. In these trainings, there are presentations by experts in the field of STEM, and STEM activities given by expert trainers. In STEM applications, students are expected to develop an engineering product using technology (including science

lab materials) in various science subjects. For the rest of the day and on Sunday, students are allowed to participate in social activities such as visiting the sea, playing sports, and attending parties. Such STEM practices, which contain information about STEM professions and provide effective teaching and individual support to students, not only encourage students' motivation to learn, but also motivate students to choose a STEM jobs in the future (Aeschlimann et al., 2016). *STEM-related elective courses* in science education colleges are more formal than these camps and they are training activities in which STEM implementations are conducted in a laboratory environment. It can be considered that these courses have a positive impact on motivation towards STEM fields, thanks to effective STEM practices and classroom experiences. This finding is consistent with the study by Starr et al. (2020), that showed the improvement of university students' STEM motivation (expectation-value beliefs), STEM identity, and STEM career goals over time with the effective science practices and classroom experiences. Other STEM training of highly motivated students is the *certificate programs* offered by private institutions for a fee. These programs are approximately 40 h and are usually based on coding on Arduino, Lego Mindstrom, and other well-known coding programs. In the first part of these certificate programs, students learn and practice programming with block-based codes; in the second part, they make STEM-Robotics applications. According to the content of the microcontroller used, students build and operate smart circuits using the programs they prepare with block codes and develop different products with the help of these circuits.

In addition to the influence of STEM training (certified), our findings determined that there is a significant increase in the motivations of the students who participated in STEM activity (uncertified) such as STEM-related congresses, seminars, chats, panels, etc. In such activities, students have the opportunity to meet, communicate and listen to the ideas of authorities working in STEM fields. It can be considered that these opportunities have a positive effect on students' motivation towards STEM fields and some students may even adopt these people as role models. This is notable because our findings indicate that the variable of having a role model working in STEM fields is another factor that positively affects their motivation towards STEM fields.

The role model is known as a person who is modeled and imitated based on their behavior, personal characteristics, or some other special qualities. Role models have a feature that has direct or indirect effects on individuals' decision-making behavior, character formation and development. González-Pérez et al. (2020), as a result of the role model intervention they conducted with students

aged 12 to 16, concluded that students with role models had a positive and significant effect on their enjoyment of mathematics, their emphasis on mathematics, their expectation of success in mathematics, and girls' desire in STEM. Stout et al. (2011) stated that interacting with the same gender STEM professionals supports implicit identification, greater self-efficacy in STEM, and more effort on STEM tests. Also, they concluded that seeing STEM professionals of the same gender predicts enhanced self-efficacy, domain identification, and commitment to pursue STEM careers. Furthermore, Dilek (2019), found significantly higher STEM career interests and self-efficacy perception in science and technology literacy among students whose role models have a job in a STEM field compared with other students. It has been estimated that the low motivation of the students who did not participate in a STEM education or activity is mostly related to the low scores from the "Expectations for Success in STEM Careers" dimension of VESAS. Expectations for success have a strong relationship with self-efficacy, and Çorlu (2012) provided strong evidence that STEM teaching experiences support pre-service mathematics and science teachers to develop high self-efficacy beliefs. Similarly, the source of low motivation of students without a role model in the STEM field may be related to the low scores in the "Expectations for Success in STEM Careers" sub-dimension related to self-efficacy. When the total scores of items between the subscales of VESAS were compared, it was found that there was a significant difference. Specifically, the total scores of the VESAS subscale 'Expectations for Success in STEM Careers' was lower than total scores of subscale 'Perceived Value of STEM fields'. This result also gives clues that students in science education college value the STEM fields, but they do not have high expectations for success. This finding also reveals how important it is to participate in STEM practices that will contribute to self-efficacy in raising motivations related to expectation for success.

In this study, female science education college students, whose data were collected, were deliberately limited to third- and fourth-year students in a narrow age range, for reasons that were explained in the limitation section. No significant difference was found between the motivation of the third- and fourth-year students towards STEM fields. This result is related to both the closeness of the ages of the students at two different grade levels and the stabilization of the motivation of the students towards STEM fields, even if they are at different grade levels, due to their advanced ages (Rosenzweig & Wigfield, 2016; Wigfield et al., 2015). According to the literature, it is seen that students' motivations in different subject areas show a negative correlation with age. For example, Jacobs et al., (2002) in their longitudinal study conducted

with the same students over a wide period from the 1st to the 12th grade, concluded that as the age of the students increased, their perceptions of self-competence and task values related to mathematics, language and sports decreased. Similarly, in a study with high school students, Kızılay (2018) concluded that as the grade level increases, the students' STEM motivation scores decrease. However, some studies have indicated that the motivation of many students will decrease over time in different STEM subject areas and become stable in later years (Rosenzweig & Wigfield, 2016; Wigfield et al., 2015).

Another variable that we investigated related to the effect of students' motivation towards STEM fields was the type of high school from which students studying in science education college graduated. These variable values were analyzed the following 2 types of high schools: Anatolian high schools and others (science high schools, religious high schools, and vocational-technical Anatolian high schools), as can be seen in Table 1. Although Anatolian high schools, science high schools, religious high schools, and vocational-technical Anatolian high schools are the schools received the most students in Turkey, most students who enroll in science education college are students who graduated from Anatolian high schools. Science high schools prepare students with high abilities in the fields of science and mathematics for higher education in these fields. Anatolian high schools prepare students for higher education institutions by providing education in programs such as social sciences, literature, and foreign language, apart from numerical programs such as science and mathematics, according to the interests, abilities and achievements of the students. Religious high schools, along with religious education, prepare students for entering professions or pursuing higher education by providing education in different programs according to their preferences, which is like the non-religious Anatolian high schools. In Vocational and Technical Anatolian High Schools, where applied education is predominant, students are given knowledge and skills for a profession. Although Wang and Degol (2013) determined and detailed the effect of school structure and type on student STEM motivational beliefs, no statistically significant difference was found in the motivation of students who graduated from different high school types participating in this research towards STEM fields. However, it was determined that the motivation scores for STEM fields of college students who graduated from science high school were higher than students who graduated from other high school types. Since the number of participants who graduated from science high schools and enrolled was very low, they could not be subjected to discrete analysis and were included in the others.

No statistically significant difference was found between the total motivation toward STEM scores of science education college students with differences in family income level and mother's education level. However, it was found that there was statistically significant difference between participants' scores of 'total VESAS', 'expectations for success in STEM careers' and their fathers' educational levels. The total motivation scores of the participants whose fathers are high school graduates are higher than those whose fathers are secondary/primary school graduates. This result reveals the effective role of high school graduate fathers in motivating their children towards STEM fields. Details of this effect may require further research to be scrutinized. However, it has been estimated that the underlying reason for this result seems to be the desire of fathers who have completed primary, secondary and high school education but could not graduate from university, to compensate for this incompleteness in their life via their children. Socio-economic variables such as parental education level and family income are more effective on the motivation of students at lower levels (secondary school, high school, etc.) towards their STEM careers (Eccles, 2009), while these variable effects are less pronounced for students at university level. Harackiewicz et al. (2012) underlined that parents can play a critical role in encouraging students' motivation towards STEM careers, but may not have the knowledge and support to do so. Svoboda et al. (2016) stated that parent education supports students to choose mathematics and science courses in high school and university, while Wang and Degol (2013) stated that the lack of resources and connections used by low-income families to support mathematics and science learning will affect STEM motivation. However, Chachashvili-Bolotin et al. (2016) found that choosing a suitable university for a STEM career is the student's own decision, and parent education level is only related to their children's entry into any higher education. Additionally, the same researchers found that socio-economic level did not affect entry to higher education, but students with a low socio-economic background were more likely to be interested in STEM fields due to financial concerns. However, Chen and Simpson (2015), in their study on university students, concluded that socio-economic level (parent education level—family income) is not an effective variable in choosing a career for students in STEM fields.

## Conclusion

This quantitative research employing a survey model has reported a multivariate assessment of 309 female science education college students' motivations for STEM fields. It has been found that female science education college students' motivations towards STEM fields differ according to

four variables: "father's education level", "having received STEM education", "having participated in STEM activities", and "having a role model working in a STEM field". In this respect, the results obtained from this study are valuable for the design of possible intervention studies in the future. Designing role model interventions, incorporating STEM trainings into education college programs, and organizing more STEM activities within education college programs are considered as important steps to increase the motivation of female science education college students. Based on this research result, the proposed intervention studies may not impact the career choice of the vast majority of pre-service science teachers, because most of these students enrolled in this college have already chosen a certain career. However, increasing the motivation of prospective science teacher candidates towards STEM fields with various interventions has indirect importance for them to motivate their students to consider STEM fields in their future professional life.

## Limitations and suggestions for future studies

It is assumed that student awareness of STEM education and STEM fields will increase after they encounter the concept of STEM education in their field education courses which are taught in the first two years of the Science Education College curriculum as determined by the Turkish Council of Higher Education (2018). In this respect, the study group from which the data were collected was deliberately limited to the third- and fourth-year female students of science education college who already have some STEM awareness. Additionally, STEM is new in other universities programs, except for education college programs, in Turkey. Therefore, there are limitations in demographic variables as well, such as major of university, gender, which may be addressed in future studies.

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### Availability of data and materials

The data generated and analyzed during the current study are available anonymized from the corresponding author by request.

## Declarations

### Ethics approval and consent to participate

All of the procedures performed in studies involving human participants were in accordance with the ethical standards and the Helsinki Declaration and its later amendments or comparable ethical standards.

## Competing interests

The authors declare that they have no competing interests.

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