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Abstract

The aim of this study is to examine the relationship between middle school students' attitudes towards robotic coding and their STEM career interests. For this purpose, data were collected from a total of 213 students studying in three different secondary schools in a province in the south of Turkey. The "STEM Career Interest" scale and the "Robotic Coding Attitude" scale were used as data collection tools. The analysis of the data indicated that there was a moderate, statistically significant relationship between the participants' attitudes towards robotic coding and their STEM career interests. When the data were analyzed in terms of sub-dimensions, a medium-level significant relationship was found between the participants' attitudes towards robotics and their science, mathematics, and engineering career interests, and a high-level significant relationship was found between their technology career interests. Additionally, sub-factors of robotic coding attitude (interest, motivation, desire to learn, self-efficacy, and anxiety) significantly predicted the participants' STEM career interests. Accordingly, it can be posited that as participants' attitudes towards robotic coding evolve, their interest in STEM careers also expands. Consequently, it is postulated that all activities that enhance attitudes and boost interest in robotic coding, whether conducted within or outside the school environment, will facilitate students' pursuit of a STEM-related career in the future.

Introduction

In order to adapt to ever-changing global conditions, educational reforms are being introduced. These reforms integrate various learning approaches into the system, creating an interdisciplinary teaching environment by bringing together different disciplines. A key goal is to actively incorporate technology into these processes. Furthermore, it is stated that the learning environments designed for this purpose will provide a foundation for students to transfer their experiences to real life by concretizing the abstract concepts they encounter. The STEM learning approach is of paramount importance for enabling students to transfer their experiences into practical, real-world applications. STEM is an interdisciplinary approach that integrates science, mathematics, technology, and engineering applications holistically (Wilson et al., 2021).

In some studies, STEM is used to describe the teaching of science and mathematics. In others, it is defined as an approach that utilizes inquiry and project-based learning techniques, replacing traditional teaching methods (Breiner et al., 2012). Nevertheless, it is asserted that STEM education encompasses more than the four disciplines that constitute STEM (Sanders, 2009). STEM education is considered essential for providing skills that address societal needs in the context of technological advancement (Honey et al., 2014; Kelley & Knowles, 2016; Moore & Smith, 2014). This is because STEM education offers contexts inspired by real-world problems and has a multidimensional structure (Dare et al., 2021).

Additionally, the global economy motivates countries to engage in research and innovation, and compels educators to train students to keep pace with technological developments (Kier et al., 2014). In this context, realizing STEM learning has become a significant scientific endeavor for teachers and researchers, aimed at enhancing students' competencies and fostering awareness of their future career interests (Kopcha et al., 2017). A major indicator of this initiative is the difficulty students report in identifying realistic strategies that will help them achieve their career goals, including selecting appropriate coursework and extracurricular activities for those pursuing STEM careers (Csikszentmihalyi & Schneider, 2000; Schneider & Stevenson, 1999). Students' STEM career perceptions are shaped by their understanding and knowledge in the areas of expectations, awareness, and skills (Franz-Odendaal et al., 2016; Mohtar et al., 2019; Wyss et al., 2012).

There is a need for change in educational environments to improve students' STEM awareness and enable them to attain STEM career awareness in the future (Tey et al., 2020; Cheng et al., 2021). At this point, it is imperative to enhance pedagogical practices in STEM-focused learning environments. Consequently, many countries are seeking the most effective implementation strategies to elevate the quality of STEM education (Thomas & Watters, 2015). In this context, educational robotics applications have recently been introduced to diversify STEM education practices. The majority of robotics applications in educational processes are utilized as a means of developing fundamental technical skills in programming (Alvarez & Larrañaga, 2016; Chaudhary et al., 2016; Kong et al., 2020; Ohnishi et al., 2017). In educational settings where robotics are incorporated, students develop a conceptual framework by designing robots through programming, thus gaining a deeper understanding of the products they create (Ching et al., 2019). It is emphasized that students' positive interest in STEM is enhanced by the understanding they develop through their interaction with robotics (Benitti, 2012; Ioannou & Makridou, 2018).

Moreover, the implementation of robotics within the context of STEM education has the potential to positively influence students' future career decisions. By acquiring knowledge and skills, students may develop an interest in and awareness of STEM, potentially leading to a STEM-related career (National Research Council, 2011; 2013). In this context, robotics applications are recognized as effective methods that can direct students' interests and career perceptions toward STEM fields (Alemdar & Rosen, 2011; Freeman et al., 2017; Gomoll et al., 2016; Nugent et al., 2016; Sisman et al., 2020). However, to encourage students to pursue a career in STEM, it is essential to raise their awareness of career opportunities in these fields at an early age (Moore & Richards, 2012; Wyss et al., 2012). It is evident that students aspiring to pursue STEM careers must develop an awareness of these disciplines before high school (Spencer, 2011). It is commonly accepted that the optimal period for students to consider pursuing a career in STEM is during their middle school years, as this is when their career interests typically begin to emerge (Wyss et al., 2012; Kier et al., 2014; Tai et al., 2006).

Considering all these factors, it is crucial to examine the variables affecting middle school students' STEM career interests and their relationship with attitudes towards robotic coding. In this context, the aim of this study is to examine the relationship between middle school students' attitudes towards robotic coding and their STEM career interests. To achieve this objective, the following research questions were posed::

- What is the level of participants' attitudes towards robotic coding?
- Do participants' attitudes towards robotic coding differ significantly according to gender?
- Do participants' attitudes towards robotic coding differ significantly according to taking a course related to robotics?
- Do participants' attitudes towards robotic coding differ significantly according to parental occupation?
- What is the level of STEM career interest of the participants?
- Do participants' STEM career interests differ significantly according to gender?
- Do participants' STEM career interests differ significantly according to taking a course related to robotics?
- Do participants' STEM career interests differ significantly according to parental occupation?
- Is there a significant relationship between participants' attitudes towards robotic coding and their STEM career interests?
- Do the sub factors of robotic coding attitude predict significantly STEM career interest of students?

Method

In this study, which aims to examine the relationship between middle school students' robotic coding attitudes and their STEM career interests, a correlational research model is used. Correlational research is a type of quantitative research in which the researcher investigates relationships or associations between two or more variables (Fraenkel & Wallen, 2009). The goal of correlational research is to determine whether and to what degree there is a relationship between the variables.

Sample

The sample for this study consisted of 213 middle school students from three different secondary schools in a province in the south of Turkey. In this study, the convenient sampling method known as convenience sampling was employed. This method is a sampling method that provides advantages in terms of time and cost and the units that are easy to reach are selected as sample (Büyüköztürk et al., 2017). This method can be considered as a limitation. To reduce limitations, schools with similar socioeconomic levels were selected for inclusion in the study. The demographic characteristics of the participants are given in Table 1. It is seen that there are more female students (56%), very few participants have taken a course or course related to robotics before (26.3%), and very few participants' parents have a profession related to STEM fields (engineers, etc.).

Table 1. Demographic Characteristics of the Participants

Variables		N	%
Gender	Woman	120	56.3
	Male	93	43.7
Classroom	Grade 6	106	49.8
	Grade 7	71	33.3
	Grade 8	36	16.9
Taking a course related torobotics	Yes	56	26.3
	No.	157	73.7
Parental occupation related to STEM field	Yes	47	22.1
	No.	166	77.9

Data Collection Tools

In this study, the "Robotic Coding Attitude Scale" and the "STEM Career Interest Scale," along with a data collection form that includes questions about participants' demographic characteristics, such as gender, were employed as data collection tools.

STEM Career Interest Scale

The "STEM Career Interest Scale" is used to determine the participants' career interests in STEM fields. This scale was developed by Kier et al. (2014) and was adapted into Turkish by Hiğde (2018). It is based on a 5-point Likert scale and consists of 44 items divided into four sub-dimensions: science, mathematics, technology, and engineering. The internal consistency of the scale, as indicated by the Cronbach's Alpha value, was 0.77 for science, 0.85 for mathematics, 0.89 for technology, and 0.86 for engineering in the original study, and 0.80 for science, 0.81 for mathematics, 0.82 for technology, and 0.80 for engineering in this study.

Robotic Coding Attitude Scale

The "Robotic Coding Attitude Scale" is used to assess the participants' attitudes towards robotic coding. The scale was developed by Altun Yalcin, Kahraman, and Yılmaz (2020). It employs a 5-point Likert scale and includes 22 items, organized into five sub-dimensions: interest, motivation, desire to learn, self-efficacy, and anxiety. The internal consistency of the scale, as measured by the Cronbach's Alpha coefficient, was 0.91 in the original study and 0.89 in this study.

Data Analysis

Descriptive statistics were calculated for the data obtained in this study, including mean and percentage values.

Additionally, the normal distribution of the data was assessed using kurtosis and skewness values, confirming that the data were normally distributed. An independent sample t-test was conducted to evaluate differences in attitudes towards robotic coding and STEM career interests based on gender, participation in a robotics-related course, and parental occupation in a STEM field. Pearson correlation analysis was also conducted to examine the relationship between participants' attitudes towards robotic coding and STEM career interests. The strength of the relationship was interpreted according to the criteria used to evaluate the r value resulting from the correlation.

- 0.30 is a low-level relationship,
- 0.30 - 0.70 is a moderate relationship
- 0.70 - 1.00 is defined as a high-level relationship (Büyüköztürk, 2009).

In addition multiple regression tests were conducted in order to predict relationship between variables. All the assumptions of the tests were checked and ensured that they were met before applying the tests (Multiple normality, multicollinearity, singularity etc.).

Validity and Reliability

The original articles of all the scales used in this study were thoroughly examined, and it was confirmed that construct validity studies had been conducted. Furthermore, content validity was carefully considered, ensuring that the scales were appropriate for the sample group. Reliability calculations (Cronbach's alpha) were performed for each scale and were reported both in the original studies and in this study. Additionally, statistical errors were mitigated by testing the prerequisites of the analyses, such as normality and multicollinearity. During the data collection process, only demographic information was gathered, excluding any personally identifiable data like names or surnames. Moreover, the scales included in the data collection tool were administered simultaneously during the data collection process.

Findings

Table 2 indicates that the mean of attitude of the participants towards robotic coding is 3.065, which corresponds to the "medium" level on the scale. This suggests that the participants' attitudes towards robotic coding are neither negative nor positive, but rather undecided.

Table 2. Participants' Attitudes towards Robotic Coding

	N	Min	Max	Mean	Sd
Robotic Coding Attitude	213	1.00	4.91	3.065	1.081

Table 3 indicates that there is no significant difference in attitudes towards robotic coding between male and female participants (p=.255, $t_{(211)}$ =-1.217). Consequently, it can be concluded that the attitudes of male and female students towards robotic coding are comparable. Nevertheless, although the difference is not statistically significant, an analysis of the averages reveals that male students exhibit slightly more positive attitudes towards robotic coding than female students.

Table 3. Change of Participants' Attitudes towards Robotic Coding according to Gender

Gender	N	Mean	Sd	t	df	P
Woman	120	2.9856	1.04985	-1.217	211	.225
Male	93	3.1672	1.11776			

Table 4 indicates that there is a significant difference between the attitudes of participants who have taken a course on robotics compared to those who have not ($p < 0.05$). Upon examination of the averages, it can be concluded that those who have taken course related to robotics exhibit a more favorable attitude towards robotic coding than those who have not.

Table 4. Change of Participants' Attitudes towards Robotic Coding according to Taking Courses related to Robotics

Taking a course relatedto robotics	N	Mean	Sd	t	df	P
Yes	56	3.3596	1.11200	2.402	211	.017
No	157	2.9598	1.05376			

Table 5 indicates that there is no significant difference in the attitudes of participants towards robotic coding according to whether their parents' profession is related to STEM fields (p=.604, $t_{(211)}$ =.520). Therefore, it can be concluded that the participants' attitudes towards robotic coding are not influenced by whether their mother or father's profession is related to STEM fields. Nevertheless, although the difference is not statistically significant, an examination of the averages reveals that the attitudes towards robotic coding of those whose mother or father's profession is related to STEM fields, such as engineering etc., are slightly higher than those who are not.

Table 5. Change of Participants' Attitudes towards Robotic Coding according to Parental Occupational Status

Parental occupation related to STEM field	N	Mean	Sd	t	df	p
Yes	47	3.1373	1.18722	.520	211	.604
No	166	3.0444	1.05221			

As indicated in Table 6, the mean STEM career interest of the participants is 3.189. This mean range corresponds to the "medium" level on the scale.

Table 6. Participants' STEM Career Interest Levels

	N	Min	Max	Mean	Sd
STEM Careers	213	1.00	5.00	3.1892	1.08719
-Science Career	213	1.00	5.00	3.2753	1.11550
-Mathematics Career	213	1.00	5.00	3.2309	1.21360
-Technology Career	213	1.00	5.00	3.2612	1.21213
-Engineering Careers	213	1.00	5.00	2.9893	1.21095

Consequently, it can be posited that the participants' levels of interest in pursuing a career in STEM are not low, but rather at the medium level. Once more, when considered in the context of the sub-dimensions, it can be stated that the participants' career interests in science, mathematics, technology and engineering are also at the "medium" level.

According to Table 7, it is seen that the STEM career interests of the participants do not differ significantly according to gender (p=.974; t(211) =.032) so it can be concluded that the career interests of male and female students in STEM fields are similar. Yet, although the difference is not statistically significant, an examination of the averages reveals that girls' career interests in science and mathematics are slightly higher than those of boys, while boys' career interests in technology and engineering are slightly higher than those of girls.

Table 7. Change of Participants' STEM Career Interest Levels according to Gender

	Gender	N	Mean	Sd	t	df	p
STEM Careers	Woman	120	3.1913	1.01964	.032	211	.974
	Male	93	3.1865	1.17426			
-Science Career	Woman	120	3.3439	1.01822	1.020	211	.309
	Male	93	3.1867	1.22975			
-Mathematics Career	Woman	120	3.2727	1.15239	.570	211	.569
	Male	93	3.1769	1.29264			
-Technology Career	Woman	120	3.1856	1.13113	-1.034	211	.302
	Male	93	3.3587	1.30908			
-Engineering Careers	Woman	120	2.9629	1.18041	-.361	211	.718
	Male	93	3.0235	1.25488			

According to Table 8, it is seen that the participants' STEM career interests differs significantly according to the status of taking a course related to robotics ($p<.05$).

Table 8. Change of participants' STEM career interest levels according to taking a course related to robotics

	Taking a course related to robotics	N	Mean	Sd	t	df	p
STEM Careers	Yes	56	3.4765	1.06822	2.327	211	.021
	No.	157	3.0867	1.07878			
-Science Career	Yes	56	3.5601	1.08105	2.246	211	.026
	No.	157	3.1737	1.11333			
-Mathematics Career	Yes	56	3.4919	1.21817	1.886	211	.061
	No.	157	3.1378	1.20216			
-Technology Career	Yes	56	3.5763	1.18813	2.288	211	.021
	No.	157	3.1488	1.20443			
-Engineering Careers	Yes	56	3.2776	1.23551	2.091	211	.038
	No.	157	2.8865	1.18918			

When the sub-dimensions are examined, it is seen that the participants' career interests in science, technology and engineering differed significantly ($p<.05$) according to the status of taking a course related to robotics, but their career interests in mathematics do not differ significantly ($p=.061, t_{(211)}=1.886$). Accordingly, it can be said that those who take a course or course related to robotics have higher career interests in science, technology and engineering in the context of STEM than those who have not.

Table 9 indicates that there is no significant difference in the participants' STEM career interests according to whether their parents' occupations are related to the STEM field ($p=.652$, $t_{(211)}=-.452$). Therefore, it can be concluded that the participants' STEM career interests are not influenced by whether their mother or father's profession is related to the STEM field.

Table 9. Change of Participants' STEM Career Interest Levels according to Parental Occupation

	Parental occupation related toSTEM field	N	Average	Ss	t	sd	p
STEM Careers	Yes	47	3.0600	1.38887	-.452	211	.652
	No.	166	2.9693	1.15953			
-Science Career	Yes	47	3.2147	1.29097	-.182	211	.856
	No.	166	3.1820	1.02654			
-MathematicsCareer	Yes	47	3.2766	1.26720	-.009	211	.993
	No.	166	3.2749	1.07290			
-TechnologyCareer	Yes	47	3.2573	1.36513	-.168	211	.867
	No.	166	3.2234	1.17156			
-EngineeringCareers	Yes	47	3.2650	1.42217	-.024	211	.981
	No.	166	3.2601	1.15061			

As indicated in Table 10, there is a positive and moderately significant relationship between the participants' attitudes towards robotic coding and their STEM career interests. To gain further insight into this relationship, the association between the participants' attitudes towards robotic coding and their STEM career interests was also examined in terms of sub-dimensions.

Table 10. The Relationship between Participants' Robotic Coding Attitudes and STEM Career Interests

	1	2
1-Robotic Coding Attitude	-	$.654^{**}$
2-STEM Career Interest		-

When analyzed in terms of sub-dimensions, according to Table 11, there is a positive and medium levelsignificant relationship between the participants' attitudes towards robotic coding and their science, mathematics and engineering career interests, and a positive and high-level significant relationship between their technology career interests. Accordingly, in general, it can be said that there is a relationship between students' attitudes towards robotic coding and their STEM career interests.

Table 11. The Relationship between Participants' Robotic Coding attitudes and Their Career Interests in STEM Fields

	1	2	3	4	5
1-Robotic Coding Attitude	-	.569**	.510**	.718**	.596**
2- Science Career		-	.882**	.779**	.752**
3- Mathematics Career			-	.757**	.728**
4- Technology Career				-	.806**
5- Engineering Careers					-

**p<.01

Regression analysis was performed to examine the predictive power of the statistical relationship and shown in Table 12.

Table 12. Results of Regression Analysis between sub factors of Robotic Coding Attitude Internet Addiction

Variable	B	Std. Error	β	t	p
Constant	77.800	9.718		8.006	.000
Interest	1.814	1.075	.240	1.687	.093
Motivation	3.294	.946	.556	3.483	.001
Desire to learn	2.078	1.088	-.219	-1.909	.058
Self-efficacy	1.223	1.334	.126	.917	.360
Anxiety	-3.224	1.064	-.152	-3.030	.003

$r = .717$, $R^2 = .514$, $F_{(5-212)} = 43.731$, $p < .001$

In Table 12, the results of the regression analysis are given. When Table 12 is examined, it can be seen that the model which included sub factors of Robotic Coding Attitude scale (interest, motivation, desire to learn, self-efficacy, and anxiety) significantly predicts the participants' STEM career interests (r = .717, R2 = .514, F(5 - 212) = 43.731, p < .001). Moreover, this model explains about 51% of the change in the participants' STEM career interests. According to the standardized regression coefficients, the relative importance of the predictive variables on STEM career interests are interest (β =.240), motivation (β =.556), desire to learn (β =-.219), self-efficacy (β =.126) and anxiety (β =-.152) respectively. When the significance levels of the regression coefficients are taken into consideration, it is seen that only motivation (p = .001) and anxiety (p = .000) variables are significant predictors of STEM career interests.

Discussion and Conclusion

This study investigates the relationship between middle school students' attitudes towards robotic coding and their perceptions of STEM careers. The findings reveal that the participants' attitudes towards robotic coding and their interests in STEM careers are at a moderate level. These results indicate that while middle school students generally show interest in robotic coding and STEM careers, this interest has not yet reached a sufficient level. Previous studies have highlighted that career interests in STEM fields are not at the desired level (Cetin & Temiz, 2019; Deming & Noray, 2018). These results underscore the importance of fostering students' interest in STEM fields and encouraging them to pursue careers in these areas.

Furthermore, the study found no significant difference between male and female students' attitudes towards robotic coding and STEM career interests. Despite the absence of a significant difference, it is observed that, in general, career interests related to STEM fields are slightly higher among males than females. This finding suggests that gender is not a determining factor in the STEM attitudes and career perceptions of students in this age group. Some studies have similarly concluded that gender is not a determining factor (Sungur Gul & Ateş, 2021). However, other studies have identified differences between male and female students in terms of STEM career interests. For instance, some studies have shown that male students tend to exhibit greater career interest in technical fields (e.g., engineering and technology), while female students are more likely to be interested in basic sciences (e.g., mathematics and science) (Aktaş, 2019; Azgin, 2019; Badur & Timur, 2020; Christen & Knezek, 2017; Gulhan & Sahin, 2018; Karakaya, Avgin, & Yilmaz, 2018; Sadler et al., 2012; Wang et al., 2013). Conversely, some studies have suggested that female students may have higher career interest in STEM fields (Urunibrahimoglu, 2019; Kiriktaş & Sahin, 2019).

Similarly, the occupation of the parents does not appear to influence the participants' attitudes towards robotic coding and STEM career interests. This suggests that, contrary to expectations, there is no direct relationship between parental occupation and students' STEM-related career perceptions. Some studies have also found that parental occupation is not a determining factor (Aktaş, 2019).

On the other hand, students who had previously received education on robotics exhibited more positive attitudes towards robotic coding and a higher interest in science, technology, and engineering careers within the STEM framework. The results demonstrate that courses incorporating robotic coding activities positively influence students' perceptions of careers in STEM fields. This is further supported by the significant correlation found between students' attitudes towards robotic coding and their STEM career interests. In particular, the high correlation between students' attitudes towards robotic coding and their career interests in technology and engineering suggests a potential pathway for increasing interest in these professions. Consequently, it can be hypothesized that activities designed to enhance attitudes or stimulate interest in robotics, whether conducted within or outside the educational setting, may encourage students to pursue a career in a STEM-related field in the future.

A considerable body of research supports the idea that robotic coding activities can enhance students' interest in STEM careers (Cansevan, 2023), facilitate future career choices (Başarmak & Hamutoglu, 2019), and assist children in making informed decisions about their future professions (Oluk et al., 2018). Studies have shown that robotics activities are particularly effective in increasing interest in technology and engineering (Meco & Gorgulu-Ari, 2021). Moreover, the literature suggests that students who are interested in learning technical and scientific knowledge are more likely to choose a STEM career (Blotnicky et al., 2018; Holdren et al., 2013). In this context, an evaluation of studies conducted within the literature reveals that students' attitudes towards robotics also play an important role in fostering career awareness about STEM professions.

In conclusion, this study helps to understand the relationship between middle school students' attitudes towards robotic coding and their perceptions of STEM careers. It shows that there is a significant relationship between middle school students' attitudes towards robotic coding and their interests in STEM careers. In this context, it is thought that increasing the integration of robotic coding activities into educational processes will increase students' awareness of STEM and enable them to pursue careers in STEM professions. In general, the provision of robotic coding courses in schools or the inclusion of activities designed to enhance students' interest in STEM fields within these courses may encourage students to pursue a career in STEM. Furthermore, activities such as robotic coding competitions and STEM camps that will allow students to develop their skills in these fields can also be organized.

In addition to the aforementioned factors, this study was conducted on a sample of middle school students drawn from a single region. Therefore, it may be more beneficial for future researchers to extend the findings of this study and examine them across different groups and contexts. Additionally, it would be valuable to explore the relationship between participants' attitudes towards robotic coding and their STEM career interests in greater depth, as well as to analyze how this relationship interacts with other factors.

Notes

A part of this study was presented as an oral presentation at the 6th International Education and Innovative Sciences Congress

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