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The case of middle school students' attitudes towards STEM on predicting their perceptions of innovative thinking*

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Abstract

This study aimed to determine the case of middle school students' attitudes towards STEM on predicting their perceptions of innovative thinking. The study was carried out using the correlational research design, and the sample consisted of 558 middle school students studying at schools in a district in Turkey's Southeastern Anatolia Region in the 2022-2023 academic year. Data were collected using the "Personal Information Form," the "Attitude towards STEM Scale," and the "Perception of Innovative Thinking Scale." Descriptive, correlational, simple, and multiple regression analyses were performed for data analysis. Analyses revealed that students had high levels of attitudes towards STEM and high levels of perceptions of innovative thinking. A positive and significant relationship was found between the attitudes towards STEM and its sub-dimensions and the perception of innovative thinking. In addition, it was found that attitudes towards STEM and its sub-dimensions significantly predicted perceptions of innovative thinking. On the other hand, the sub-dimensions of attitudes towards STEM that most significantly predicted perceptions of innovative thinking were found to be 21st-century skills, mathematics, science, engineering, and technology, in order of importance. Based on the findings, recommendations were provided.

Keywords: Attitude towards STEM, Innovative thinking, Middle school student.

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INTRODUCTION

Scientific development and technological advances of the 21st century have made it critical to raise individuals who will keep up with this age, that is, who have 21st-century skills. In the 21st century, individuals are expected to have skills such as problem-solving, critical thinking, cooperation, communication, entrepreneurship, innovation, and creativity (Yiğit, Muradoğlu, & Mazlum Güven, 2019). With innovation, one of the 21st-century skills, being given importance worldwide, raising individuals with innovative characteristics has become a priority. One of the applications that help students apply their theoretical knowledge and thus help them reach the level of innovation is STEM applications (Sarı & Yazıcı, 2019). The aim of STEM is to help students relate to everyday life what they have learned in the disciplines of science, mathematics, technology, and engineering, thus raising individuals who can innovate, produce creative solutions to problems, have an innovative perspective, and look at events critically (Durucu & Başaran, 2022; Sanders, 2009). In short, STEM education aims to transform theoretical knowledge into practice, innovative inventions, and products (Turkish Ministry of National Education [MoNE], 2021).

STEM education refers to an engineering and technological design-based teaching approach that integrates the concepts and applications of mathematics and science with the concepts of engineering and technology education (Roberts, 2012; Sanders, 2012; Wang, Moore, Roehrig, & Park, 2011). In this age of Industry 4.0, countries need citizens trained in STEM, so it is important to raise STEM-literate individuals (Lazowska, 2011). For many students, STEM disciplines are boring, complex, or difficult (Hubbard, Embry-Jenlink, & Beverly, 2015). Therefore, it is also important that students have fun while improving themselves in STEM disciplines (Hutchison, 2012). Hence, it can be said that it is crucial to help students develop positive attitudes towards STEM. Indeed, having positive attitudes towards STEM disciplines will ensure that students are willing to plan careers in these disciplines (Christensen, Knezek, & Tyler-Wood, 2015).

Innovativeness is expressed as being more willing than other individuals in the system to accept novel ideas and adapt to innovation (Rogers, 1995). Barak, and colleagues (2013) refer to innovative thinking as a cognitive process that leads to the implementation of new or improved ideas. Innovative thinking is a concept based on creativity and innovation and is often related to production (Yücel, Çiftçi, & Durmaz, 2022). While creativity is the ability to change an existing or new thing, innovation is the ability to produce something new with the realization of creative ideas (Grégoire, 2018). Kaufman (2013) argues that innovative and creative thinking skills are important for both today's economy and the future economy. Innovative individuals try different methods to achieve results, emphasize the process rather than the goal, are involved in more than one activity or task at a time, and tend to learn from more than one source (Wheeler, 1998). The concept of innovation is also highlighted in the 21st-century learning skills theme (Partnership for 21st-century Skills, 2008). With the international importance attached to the concept of innovation, the concepts of "innovation" and "innovative thinking" gained importance in Turkey as well (Deveci & Kavak, 2020). In this context, the "engineering and design skills" learning area in the "2018 science curriculum" covers innovative thinking (MoNE, 2018).

Students with STEM education are expected to have 21st-century skills, such as problem-solving, communication, logical thinking, innovation, and critical thinking (Morrison, 2006; Savaş & Şeker, 2022). The "engineering and design skills" learning area in the current science curriculum covers many disciplines (mathematics, science, engineering, and technology), which aim to enable students to reach the level of innovation and invention and to create products using their knowledge and skills (MoNE, 2018). In short, STEM education forms the basis of innovation and entrepreneurship skills that are necessary for innovations to be introduced to the market (Deveci, 2018). Therefore, it can be said that one of the aims of STEM education is to cultivate innovative thinking skills in students. Individuals involved in STEM education are usually creative, problem-solving, self-confident, and innovative

(Morrison, 2006). This is because STEM applications are usually accompanied by learning settings where students can think freely, cooperate, produce original ideas, and realize these ideas. Both STEM education and innovative thinking aim to produce a product, which is an indication that STEM education and innovative thinking have common goals.

The review of the relevant literature revealed that only a limited number of studies have been conducted to explore the correlations between thinking skills (critical thinking, decision-making, creative thinking, analytical thinking, etc.) and STEM self-efficacy, STEM awareness, and STEM attitude. These studies include Deveci (2018), who investigated how pre-service teachers' STEM awareness predicted their entrepreneurial characteristics; Aydın Gürler (2022), who researched how pre-service teachers' STEM self-efficacy predicted their critical thinking disposition; and Deveci and Konuş (2022), who studied how middle school students' entrepreneurial competencies predicted their STEM attitudes. According to Deveci and Kavak (2020), the studies on innovation were mostly conducted with teachers, teacher candidates studying at faculties of education, and other university students, and the number of studies on innovation at the primary or middle school level is quite limited. On the other hand, it is stated that students generally do not have sufficient awareness of innovative thinking, their creative and innovative thinking skills are quite low, and schools fail to educate students as innovative individuals (Ma, Zhang, & Liu, 2018).

Middle school is a critical period when students begin to make career plans and develop knowledge, attitudes, and behaviors related to professions (Gottfredson, 2002). Knezek, Christensen, Tyler-Wood, and Periathiruvadi (2013) emphasize the importance of the middle school period for the manpower trained in STEM disciplines that countries will need. In addition, Rábanos and Torres (2012) state that with the acceleration of social and cognitive development, middle school children will have more advanced thinking skills. For these reasons, it is important to help middle school students develop attitudes towards STEM and the 21st-century skills necessary for STEM activities. Deveci (2018) argues that students in classes where STEM activities are performed have better innovative thinking capacities. In this context, it is expected that students who willingly participate in STEM activities, that is, who have positive attitudes towards STEM, will be more productive, that is, they will have higher levels of perception of innovative thinking. Taking these as a starting point, the current research aimed to determine the case of middle school students' attitudes towards STEM on predicting their perceptions of innovative thinking. To this end, the research sought answers to the following sub-problems:

1. What are students' attitudes towards STEM?
2. What are the perception levels of students towards innovative thinking?
3. Is there a significant relationship between the attitudes towards STEM and its sub-dimensions and the perception of innovative thinking?
4. Does the attitude towards STEM significantly predict the perception of innovative thinking?
5. Do the sub-dimensions of the attitude towards STEM significantly predict the perception of innovative thinking?

METHOD

Research Design

Aiming to examine the relationship between students' attitudes towards STEM and their perceptions of innovative thinking, the study employed a correlational research design. The design aims to measure two or more variables and determine the relationships, if any, between the variables (Lodico, Spaulding, & Voegtle, 2010). This design includes attitudes towards STEM and its sub-dimensions as independent variables (predictor) and the perception of innovative thinking as the dependent variable (predicted).

Population and Sample

The study population consisted of a total of 15.974 middle school students studying at schools in a district located in Turkey's Southeastern Anatolia Region in the 2022-2023 academic year. The study sample, on the other hand, consisted of 558 students studying in these middle schools, who were determined based on the typical case sampling method. The schools included in the sample are similar and typical in terms of many characteristics (level of success in the secondary education entrance exam, school sizes, etc.) (Büyüköztürk, Kılıç Çakmak, Akgün, Karadeniz, & Demirel, 2012). The form containing the scales was applied to 600 students. The forms with inappropriate coding were excluded, thus the analyses were carried out on the forms of 558 students. Calculations revealed that the sample size was sufficient at a 95% confidence interval and α=.05 significance level (Field, 2009). Of the participating students, 49.28% were female and 50.71% were male. 24.91% were in the 5th grade, 26.10% were in the 6th grade, 22.93% were in the 7th grade, and 25.98% were in the 8th grade. Therefore, it can be said that students were distributed closely in terms of both gender and grade level.

Data Collection Tools

Data were collected using the "Personal Information Form," "Attitude towards STEM Scale," and "Perception of Innovative Thinking Scale."

Personal Information Form: The form developed by the researcher includes questions about participants' gender and grade levels.

Attitude towards STEM Scale: The scale was developed by the Friday Institute for Educational Innovation (2012) and adapted into Turkish by Özcan and Koca (2018). The scale consisted of 37 5-point Likert-type items and four dimensions (science, mathematics, engineering, and technology, and 21st-century skills). The internal consistency coefficient was calculated in the original study to determine the scale reliability. This value was obtained as .91 for the overall scale, .86 for the mathematics dimension, .87 for the science dimension, .86 for the engineering and technology dimension, and .88 for the 21st-century skills dimension. In addition, CFA was performed for the construct validity of the scale. In the current study, the reliability and validity of the scale were recalculated by the researcher. As a result, Cronbach's alpha value was calculated as .89 for the overall scale, .77 for the mathematics dimension, .82 for the science dimension, .80 for the engineering and technology dimension, and .84 for the 21st-century skills dimension. In addition, CFA was performed for the construct validity of the scale. In the literature, various opinions have been put forward about which goodness-of-fit values should be reported. According to Kline (2016), for example, reporting χ^2/df, *p* value of $\chi 2$, RMSEA, CFI, and SRMR indices is adequate. Hence, the current study included the said indices. The goodness-of-fit values of the model were obtained as follows: χ^2/df=1.995, *p*=0.00, RMSEA=0.042, CFI=0.901, and SRMR=0.0503. These values are at an acceptable level (Tabachnick and Fidell, 2013). Therefore, the four-factor model was also validated in this research sample.

Perception of Innovative Thinking Scale: The original scale developed by Yiğit et al. (2019) included 32 items and three factors (innovative individual, questioning individual, and traditionalist individual). Later, Muradoğlu (2020) updated the scale to include 25 items and three factors (innovative, traditionalist, and open to questioning). The scale has 5-point Likert-type items. The internal consistency coefficient was calculated in the original study to determine the scale reliability. This value was obtained as .90 for the overall scale, .88 for the innovative dimension, .76 for the traditionalist dimension, and .74 for the open-to-questioning dimension. In the current study, the reliability and validity of the scale were recalculated by the researcher. As a result, Cronbach's alpha value was calculated as .89 for the overall scale, .88 for the innovative dimension, .81 for the traditionalist dimension, and .66 for the open-to-questioning dimension. In addition, CFA was performed for the construct validity of the scale. The goodness-of-fit values of the model were obtained as follows: χ^2/df=1.995, *p*=0.00, RMSEA=0.042, CFI=0.901, and

SRMR=0.0503. These values are also at an acceptable level. Therefore, the three-factor model was also validated in this research sample.

Data Analysis

For data analysis, the study employed AMOS 21.0 (to test the construct validity of the scales) and SPSS 21.0 (to calculate the regression analysis, descriptive statistics, and Pearson product-moment correlation coefficient). A descriptive analysis was performed to determine students' attitudes towards STEM and their perceptions of innovative thinking, and a correlation analysis was used to determine the relationship between the attitudes towards STEM and its sub-dimensions and students' perceptions of innovative thinking. The correlation coefficient between .10 and .29 was interpreted as indicating a low, between .30 and .49 as indicating a moderate, and between .50 and 1.0 as indicating a high correlation between the two variables (Pallant, 2016). A simple linear regression analysis was performed to determine the state of attitudes towards STEM on predicting perceptions of innovative thinking. In addition, a multiple regression analysis was performed to determine to what extent the independent variables (sub-dimensions of attitudes towards STEM) predicted the dependent variable (the perception of innovative thinking). In order for simple and multiple regression analyses to produce accurate results, certain conditions must be met. For the simple linear regression analysis, the scatter diagram was examined, which indicated a linear relationship between the independent and dependent variables. For the data to meet the assumption of normal distribution, outliers were removed. In addition, measures of central tendency and skewness-kurtosis coefficients were examined to determine whether the predictor (attitude towards STEM) and predicted (perception of innovative thinking) variables showed a normal distribution. Measures of central tendency (mode, median, mean) were found to be close to each other, and skewness-kurtosis coefficients (for the attitude towards STEM: skewness -.040 and kurtosis -.190; for the perception of innovative thinking: skewness -.001 and kurtosis -.725) were found to be less than 1. Therefore, the distribution is normal (Can, 2019). Before starting the multiple regression analysis, certain conditions must be met. VIF values below 10 (range 1.12 to 1.65) (Belsley, Kuh, & Welsch, 1980), tolerance values above .20 (range .60 to .88) (Field, 2009), and bilateral correlations between independent variables below .90 (Büyüköztürk, 2003) showed that there was no multicollinearity problem. The skewness and kurtosis values between –1.5 and +1.5 for the independent (skewness -.050 and kurtosis .086 for the mathematics dimension, skewness -.247 and kurtosis -.427 for the science dimension, skewness -.166 and kurtosis -.219 for the engineering and technology dimension, and skewness -.376 and kurtosis -.197 for the 21st-century skills dimension) and dependent (skewness .226 and kurtosis -.458 for the perception of innovative thinking) variables showed that the data were normally distributed (Tabachnick & Fidell, 2013). There is a linear relationship between each of the independent variables and the dependent variable. In addition, it was found that the independent variables were equally distributed in the dependent variable (covariance), the errors were independent of each other, and the errors of the estimations were normally distributed.

Ethical Considerations

Before data collection, ethical committee approval was obtained from the Gaziantep University Social and Humanities Sciences Ethics Committee. In addition, necessary permissions were obtained from the scale owners via e-mail. Data were collected face-to-face from middle school students who voluntarily participated in the study in the 2022-2023 academic year. Participation in the study was voluntary, and students were asked to fill in the voluntary participation form. In addition, since the participants were under the age of 18, their parents were asked to fill in the parental consent form.

FINDINGS

Students' Attitudes Towards STEM and Perceptions of Innovative Thinking

Table 1 presents the results of the descriptive analysis conducted to determine students' attitudes towards STEM and their perceptions of innovative thinking.

Table 1. Descriptive Analysis of Attitude towards STEM and Perceptions of Innovative Thinking

Variables	N	$\bar{X}$	SD	Std. Error
1. Attitude towards STEM	558	3.57	.54	.02
2. Perception of Innovative Thinking	558	3.79	.61	.02

In the interpretation of the arithmetic means given in Table 1, it was taken into account that both scales contained 5-point Likert-type items. Accordingly, middle school students' attitudes towards STEM and their perceptions of innovative thinking were middle-high ($\bar{X}$= 3.57; $\bar{X}$= 3.79).

Relationship between Attitude towards STEM and Its Sub-Dimensions and Perception of Innovative Thinking

Table 2 presents the results of the correlation analysis conducted to determine the relationship between attitude towards STEM and its sub-dimensions and perception of innovative thinking.

Table 2. Correlation Coefficients of the Relationship between Attitude towards STEM and Its Sub-Dimensions and Perception of Innovative Thinking

Variables	1	2	3	4	5	6
1. Mathematics	1					
2. Science	.259**	1				
3. Engineering and Technology	.211**	.434**	1			
4. 21st-Century Skills	.307**	.453**	.565**	1		
5. Attitude towards STEM	.571**	.736**	.770**	.827**	1	
6. Perception of Innovative Thinking	.360**	.420**	.464**	.653**	.660**	1

**p<.01

According to the correlation coefficients in Table 2, a positive, high-level relationship exists between attitude towards STEM and perception of innovative thinking (r=.660, p<.01). On the other hand, perception of innovative thinking had a positive, moderate relationship with mathematics (r=.360, p<.01), science (r=.420, p<.01), and engineering and technology (r=.464, p<.01) sub-dimensions but a positive, high-level relationship with the 21st-century skills sub-dimension (r=.653, p<.01).

The Case of Middle School Students' Attitudes Towards STEM on Predicting Their Perceptions of Innovative Thinking

Table 3 presents the results of the simple linear regression analysis conducted to determine the case of attitudes towards STEM on predicting perceptions of innovative thinking.

Table 3. Simple Linear Regression Analysis to Determine the Case of Attitude towards STEM on Predicting Perceptions of Innovative Thinking

Variable	B	Standard error	β	t	*p*
Constant	1.103	.131		8.404	.000
STEM attitude	.752	.036	.660	20.717	.000*
R=.660	R^2=.436				
$F_{(1.556)}$= 429.184	*p*=.000				

*p<.05

The results of the simple linear regression analysis to understand whether the attitude towards STEM has a significant predictive effect on the perception of innovative thinking revealed that the attitude towards STEM was a significant predictor of perceptions of innovative thinking (R=.660, R^2=.436, $F_{(1,556)}$= 429.184, p<.05). In addition, the attitude towards STEM explains 43% of the perception of innovative thinking.

The Case of Sub-Dimensions of Attitude towards STEM on Predicting Perception of Innovative Thinking

Table 4 presents the results of the multiple regression analysis to determine the case of sub-dimensions of attitude towards STEM on predicting perception of innovative thinking.

Table 4. Multiple Regression Analysis to Determine the Case of Sub-Dimensions of Attitude towards STEM on Predicting Perception of Innovative Thinking

Variable	B	Standard Error	β	*t*	*p*
Constant	1.138	.129	-	8.824	.000
Mathematics	.133	.028	.157	4.800	.000
Science	.091	.030	.110	3.053	.002
Engineering and technology	.083	.031	.102	2.655	.008
21st-century skills	.428	.034	.497	12.528	.000
R= .689	R^2= .474	adjusted R^2= .470			
F(4, 553)=124.700	*p*= .000				

Results of the multiple linear regression analysis to determine the case of variables, such as mathematics, science, engineering and technology, and 21st-century skills (which are thought to have an impact on students' perception of innovative thinking) on predicting perception of innovative thinking revealed that students' innovative thinking perceptions were significantly predicted by the sub-dimensions of mathematics (β=.157, t=4.800, p<.05), science (β=.110, t= 3.053, p<.05), engineering and technology (β=.102, t= 2.655, p<.05) and 21st-century skills (β=.497, t= 12.528, p<.05). An increase of 1 unit in the "mathematics" sub-dimension results in an increase of .157 unit in the perception of innovative thinking, an increase of 1 unit in the "science" sub-dimension results in an increase of .110 unit in the perception of innovative thinking, an increase of 1 unit in the "engineering and technology" sub-dimension results in an increase of .102 unit in the perception of innovative thinking, and an increase of 1 unit in the "21st-century skills" sub-dimension results in an increase of .497 unit in the perception of innovative thinking. On the other hand, 47% of the perception of innovative thinking is explained by the mathematics, science, engineering, and technology and 21st-century skills sub-dimensions of attitude towards STEM ($_{adjusted}$ R^2=.470; p<.05).

DISCUSSION AND CONCLUSION

In the current study, which sought to determine the case of middle school students' attitudes towards STEM on predicting their perceptions of innovative thinking, first, students' attitudes towards STEM and their perceptions of innovative thinking were determined. It was found that middle school students had high-level attitudes towards STEM and high-level perceptions of innovative thinking. Yetkin and Aküzüm (2022) and Canbazoğlu and Tümkaya (2020) reported that primary school students, Aydın, Saka, and Guzey (2017) determined that fourth to eighth graders, and Balçın, Çavuş, and Yavuz Topaloğlu (2018) stated that middle school students had high-level attitudes towards STEM. Aras (2020) found that middle school students had moderate levels of innovative thinking skills. Deveci and Kavak (2020) concluded that 46% of middle school students participating in the study were highly inclined to think innovatively. Finally, Muradoğlu (2020) determined that middle school students' perceptions of innovative thinking were at a high level. Therefore, the results of the said studies are consistent with the results of this study.

In the current study, a positive, high, and significant relationship was found between students' attitudes towards STEM and their perceptions of innovative thinking. Further, it was seen that the attitude towards STEM was a significant predictor of perceptions of innovative thinking and explained 43% of perceptions of innovative thinking. This means that as students' attitudes towards STEM increase, their perceptions of innovative thinking increase, and their perceptions of innovative thinking decrease as their attitudes towards STEM decrease. During STEM education, students are provided with theoretical information about STEM disciplines. In addition, they are expected to transform their theoretical knowledge into practice, products, and even innovations. In short, with STEM education, students develop an innovative approach as well as gain cultural and social awareness (Bybee, 2010). With STEM education, students improve their special talents and use them to create and market innovative products. While doing so, they use their innovative thinking skills (Benek, 2019). In this sense, STEM education aims to raise individuals who can view problems innovatively, creatively, and critically (Sanders, 2009). Therefore, helping students develop positive attitudes towards STEM activities can also increase their perceptions of innovative thinking.

The perception of innovative thinking had a positive, moderate relationship with the mathematics, science, engineering and technology sub-dimensions but a positive, high-level relationship with the 21st-century skills sub-dimension. In addition, the results of the multiple linear regression analysis to determine the case of the sub-dimensions of attitudes towards STEM on predicting perceptions of innovative thinking revealed that perceptions were significantly predicted by all the sub-dimensions. Science, mathematics, engineering and technology, and 21st-century skills sub-dimensions altogether explain 47% of perceptions of innovative thinking. In short, it can be said that the attitude towards STEM is an important predictor of perceptions of innovative thinking. In other words, the change in middle school students' perceptions of innovative thinking is significantly affected by their attitudes towards STEM. On the other hand, the sub-dimensions of attitude towards STEM (which were the predictive variables) that most significantly predicted perceptions of innovative thinking were found to be 21st-century skills, mathematics, science, engineering and technology, respectively. Çatalbaş (2006) reported a significant and positive relationship between innovative thinking styles and attitudes towards science and mathematics lessons and stated that students with innovative thinking styles had more positive attitudes towards numerical lessons. In other words, students with positive attitudes towards science and mathematics lessons have more innovative thinking styles. Yorulmaz, Çokçalışkan, and Çelik (2017) concluded that as teachers' mathematical thinking levels increased, their individual innovativeness increased. Indeed, many studies in the literature indicate a direct or indirect relationship between mathematical thinking and innovation (Dennis & Hamm, 2010; Jacobson & Kozma, 2000; Van de Walle, Karp, & Bay Williams, 2014). In the current study, it was the 21st-century skills sub-dimension that had the greatest effect on the change in students' perceptions of innovative thinking. According to Partnership for 21st Century Learning (P21) data, 21st-century skills consist of three main themes: "life and career skills," "information, media, and technology skills," and "learning and innovation skills," each of which includes different skill sets. Therefore, it can be argued that innovative thinking is one of the skills that an individual should possess in the 21st century. In this respect, it is possible that the variable with the greatest effect on the change in the perception of innovative thinking is the 21st-century skills sub-dimension. On the other hand, the sub-dimension with the least effect on the change in students' perceptions of innovative thinking emerged as "engineering and technology." Lantz (2009) argues that the engineering dimension of STEM applications is not sufficiently emphasized in innovation studies for social development. Furthermore, many researchers emphasized that especially engineering-related subjects should be included in the science curriculum (Apedoe, Reynolds, Ellefson, & Schunn, 2008; Mehalik, Doppelt, & Schunn, 2008). In this context, the learning area of "engineering and design skills" was included for the first time in the 2018 science curriculum, in addition to the learning area of "scientific process skills and life skills." With this learning area, students are expected to actively use the knowledge and skills they have learned in their lessons and to participate in the product creation process. This learning area also aims to help students develop an understanding of how they can add economic value to the products they design (MoNE, 2018). In this context, the importance of innovative thinking is emphasized. However, according to some studies in the literature, the learning area of "engineering design skills" included in the curriculum does not have a theoretical background (Bakırcı & Kaplan, 2021), the curriculum does not have an adequate number of learning outcomes related to engineering design skills (Özcan & Koştur, 2019), and there are certain challenges in the application process as applications related to engineering design skills are not sufficiently associated with the learning outcomes (Saraç &

Yıldırım, 2019). Indeed, engineering skills that are not put into practice will probably fail to contribute to students' innovative thinking skills. Hence, this may explain why the sub-dimension of engineering and technology has the least effect on the change in students' perceptions of innovative thinking. Based on the study results, the following recommendations can be made.

The results obtained regarding the relationship between attitude towards STEM and perception of innovative thinking showed that students' attitudes towards STEM were an important factor in predicting their perceptions of innovative thinking. Considering that an increase in students' attitudes towards STEM also means an increase in their perceptions of innovative thinking, efforts can be made in schools to help students develop positive attitudes towards STEM. For this purpose, STEM applications can be given more space in science classes. The engineering and technology sub-dimension has the least effect on the change in the perception of innovative thinking compared to the other sub-dimensions. The learning area of "engineering design skills" in the current science curriculum aims to contribute to students' innovative thinking skills. This goal can be achieved by giving more space to the applications of engineering design skills in science classes. Efforts can be made to investigate the factors (teacher characteristics, student characteristics, teaching methods, techniques, etc.) that positively contribute to students' attitudes towards STEM and their perceptions of innovative thinking. The results to be obtained may enable new planning in some areas (teacher training, curriculum, etc.). Finally, other factors influencing innovative thinking skills, which an individual should have in the 21st century, can be investigated. The results to be obtained can contribute to the studies on the development of this skill.

Statement of Researchers

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