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Mathematical Modeling Self-Efficacy of Middle School and High School Students

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Mathematical modeling is a cyclical process involving the competencies of understanding the problem, simplifying, mathematizing, working mathematically, interpreting, and validating. Mathematical modeling self-efficacy beliefs are essential to students' mathematical modeling performance. This study examined middle and high school students' mathematical modeling self-efficacy beliefs. The participants consisted of 1091 middle school students and 974 high school students. The data were collected through the "Mathematical Modeling Self-Efficacy Scale [MMSS]". T-tests and ANOVA test statistics were used to determine the effect of gender, school level, grade level and previous engagement in model-eliciting activities on the mathematical modeling self-efficacy beliefs. The results showed that the mathematical modeling self-efficacy beliefs of middle school students were significantly higher than those of high school students. Furthermore, middle school students' mathematical modeling self-efficacy beliefs did not differ significantly by gender, while at the high school level there was a significant difference in favor of males. Regarding grade levels, only a statistically significant difference was found between the mathematical modeling self-efficacy beliefs of seventh- and eighth-grade students. Moreover, middle and high school students who had previously engaged in model-eliciting activities had significantly higher mathematical modeling self-efficacy beliefs than those who had not. In the accessible literature, there is no study on the mathematical modeling self-efficacy beliefs of middle and high school students. Therefore, we believe this study's results will contribute to the literature on mathematical modeling.

Introduction

Preparing individuals for real life is one of the general goals of mathematics education. Teaching mathematics using examples from everyday life positively affects students' cognitive and affective characteristics (Blum & Borromeo Ferri, 2009).

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Mathematical modeling is a teaching tool for developing individuals who can use mathematics in everyday situations (Blum, 2011; Gravemeijer & Stephan, 2002; Kaiser & Sriraman, 2006). According to the curricula of many countries, mathematical modeling is a skill that students should acquire (Ministry of National Education, [MoNE], 2018; National Council of Teachers of Mathematics [NCTM], 2000). Mathematical modeling supports students' acquisition of reasoning and mathematical thinking skills and helps students realize the presence of mathematics in everyday life. At the same time, it enables teachers to see and appreciate the different ways of seeing and thinking about their students (Erbaş et al., 2014). For these reasons, mathematical modeling should be integrated into learning environments (English, 2009).

Mathematical modeling uses mathematical representations to analyze, predict, and understand real-world phenomena (Lesh & Doerr, 2003). It first appeared in the curricula of developed countries in the 21st century and has since become increasingly important in mathematics education (Borromeo-Ferri, 2018). Modeling is the creation of representative descriptions of a situation for specific purposes (Lesh & Lehler, 2003), and can be described as a model-building process that produces a physical, abstract, or symbolic model of an actual situation (Lesh & Doerr, 2003). A model is a structure that helps understand a complex process (Harrison, 2001). Mathematical modeling is a multidimensional process that involves identifying, simplifying, mathematically expressing, solving, interpreting, and validating real-life problems through the development of models (Borromeo-Ferri, 2006).

The mathematical modeling process is not as straightforward, understandable, and simple as it is portrayed, but it is a complex structure with frequent transitions between steps (Berry & Houston, 1995; Doerr, 1997; Niss, 1989). According to Berry and Houston (1995), the modeling process occurs through the interaction between real life and the mathematical world; real life is formulated by moving into mathematics, and the mathematical results obtained by moving into real life are interpreted. Pollak (1979) stated that mathematical modeling is the interaction between mathematics and the world outside mathematics and pointed out that the modeling process requires revealing the relationship between mathematics and other fields. Furthermore, many researchers emphasize that modeling is cyclical and involves competencies (Blum & Borromeo-Ferri, 2009; Doer, 1997; Lesh & Doerr, 2003). Modeling competencies can be defined as an individual's ability to progress purposefully in building a model (Kaiser & Maaß, 2007) and to carry out the process independently and deliberately (Blomhøj & Jensen, 2003). Modeling competencies include cognitive skills and content knowledge; relating this knowledge to real-life completes the modeling process (Erbaş et al., 2014; Tekin Dede, 2015). Although there are different competencies in mathematical modeling processes, understanding the problem, simplifying, mathematizing, working mathematically, interpreting, and validating are common in many studies (Berry & Davies, 1996; Blum & Leiss, 2007; Galbraith & Stillman, 2006) (see Figure 1).

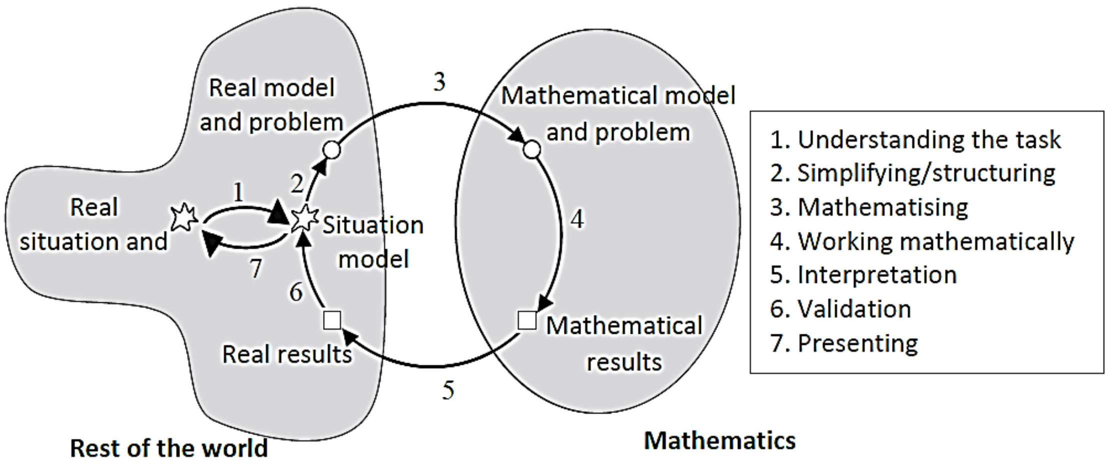

Figure 1. The modeling cycle (Blum & Leiss, 2007)

In the cyclical modeling process proposed by Borromeo-Ferri (2006), in the step of understanding the problem, students are expected to make sense of the real-life situation given in the problem and to create a structure of the problem in their minds. In simplifying, students are expected to identify the information needed to solve the problem and, if necessary, complete the missing information by drawing on their life experiences. The step in which the assumptions and thoughts are verbally explained and determined about the problem's solution is translated into mathematical language is called mathematizing. In this step, students are expected to express their thoughts through mathematical expressions, symbols, and drawings. In working mathematically, students are expected to work on the mathematical model they have created for the solution and to find a result by performing mathematical operations. Interpreting involves checking whether the results are compatible with real life. In validating, the final stage of modeling, students are expected to check the results they have obtained operationally and in real life.

The studies investigating mathematical modeling competencies at the primary and secondary education levels are relatively less than the studies conducted at the higher education level (Aztekin & Taşpınar-Şener, 2015; Uzun et al., 2023; Yenilmez & Yıldız, 2019). Studies conducted at the primary and secondary levels revealed that mathematical modeling increased students' mathematical achievement (Boaler, 2001; Yıldırım & Işık, 2015), improved their mathematical thinking skills (Brady, 2018; English & Watters, 2004; Ferri & Blum, 2013), and positively influenced their thoughts about mathematics (Boaler, 2001; Muşlu & Çiltaş, 2016; Uzun et al., 2023). Mathematical modelling skills have also been found to be related to components such as perception (Ergene, 2019; Ergene & Özdemir, 2020) or mathematical modelling self-efficacy (Erdoğan, 2019; Schöber et al., 2018). Moreover, some studies have explored the relationship between mathematical modeling competencies and variables such as grade level (Ludwig & Xu, 2010; Tekin Dede, 2015) and gender (Dede et al., 2018; Ludwig & Xu, 2010; Mehrain & Gatabi, 2014). These studies found statistically significant differences in mathematical modeling competencies according to grade level and gender. Thus, mathematical modeling competencies are related to characteristics such as attitude, anxiety, and self-efficacy, as well as variables such as grade level and gender.

Self-efficacy is an individual's belief, judgment, or prediction about their success in performing an activity (Bandura, 1977). Self-efficacy is primarily concerned with the cognitively perceived ability of the self. It involves how people evaluate their own competence in a particular area of functioning (Bong & Clark, 1999). Self-efficacy influences an individual's choice of activities, level of effort and persistence. Individuals with low self-efficacy for a particular task may shy away from it, whereas those who feel capable are more likely to engage (Artino, 2012). Students' judgments about their ability to complete mathematics tasks constitute mathematics self-efficacy (Pajares & Kranzler, 1995). In addition to mathematics self-efficacy (Hackett & Betz, 1989; Pajares & Miller, 1997) and mathematics teaching self-efficacy (Lau, 2022; Zuya et al., 2016), research has been conducted on self-efficacy in different areas related to mathematics such as mathematics literacy self-efficacy (Hiller et al., 2022), geometry self-efficacy (Erkek & Isiksal-Bostan, 2015), problem-solving self-efficacy (Pajares & Miller, 1994; Simamora & Saragih, 2019), and mathematical modeling self-efficacy (Erdoğan, 2019). Mathematical modeling self-efficacy belief refers to an individual's confidence in their ability to construct, use, and interpret mathematical models. It reflects students' confidence in effectively using their mathematical modeling capabilities (Koyuncu et al., 2017). Mathematical modeling self-efficacy belief influences mathematical thinking skills and problem-solving abilities (Doerr et al., 2017) and positively impacts mathematics achievement (Erdoğan, 2019; Schöber et al., 2018; Yel, 2021). In addition, a positive relationship has been found between students' mathematical modeling self-efficacy beliefs and mathematical modeling skills (Kelly, 2014; Smith et al., 1994). Therefore, students' self-efficacy beliefs about mathematical modeling skills are an essential factor affecting students' mathematical modeling performance (Koyuncu et al., 2017; Yıldız & Yetim, 2024).

In the available literature, we could not find any studies that simultaneously investigated and compared the mathematical modeling self-efficacy beliefs of middle and high school students. However, the fact that students' mathematical modeling skills are not sufficient at these levels has been highlighted (Deniz & Akgün, 2018; Maaβ, 2006; Özgen & Şeker, 2021; Özer & Bukova Güzel, 2016). One of the reasons for this is that students are encountering model-eliciting activities for the first time (Doerr & English, 2003; English, 2009; Uzun et al., 2023). Another reason may be students' beliefs about their mathematical modeling self-efficacy (Kelly, 2014; Smith et al., 1994). Therefore, it is essential to examine middle and high school students' beliefs about their mathematical modeling self-efficacy. In this study, we sought answers to the following research questions to examine middle and high school students' beliefs about their mathematical modeling self-efficacy.

What are students' mathematical modeling self-efficacy beliefs according to school level, gender, grade level, and previous engagement in model-eliciting activity?

- Do students' mathematical modeling self-efficacy beliefs differ by gender?
- Do students' mathematical modeling self-efficacy beliefs differ by school level?
- Do students' mathematical modeling self-efficacy beliefs differ by grade level?
- Do students' mathematical modeling self-efficacy beliefs differ by their previous engagement in model-eliciting activities?

Methodology

In this study, the descriptive survey model, one of the quantitative research methods, was used to determine the mathematical modeling self-efficacy beliefs of middle and high school students (Karasar, 2006).

Participants

The participants of the study consisted of 2065 middle and high school students in two different cities in Marmara Region in Türkiye. The participants came from families of different socio-economic status, and all were enrolled in public schools. They voluntarily took part in the study. Information about the participants is given in Table 1.

Table 1. Information about the participants

	Female			Male		
Gender	1091			974		
	52.8 %			47.2 %		
	Middle School			High School		
School Level	1077			988		
	52.2 %			47.8 %		
	6th	7th	8th	9th	10th	11th
Grade Level	294	483	300	218	180	590
	14.2 %	23.4 %	14.5 %	10.6 %	8.7 %	28.6 %
Previous engagement in model-eliciting activities	Yes			No		
	397			1668		
	19.2 %			80.8 %		

A total of 52.8% of the participants (n=1091) were female, while 47.2% of them (n=974) were male (see Table 1). Furthermore, 52.2% of the participants (n=1077) were middle school students, while 47.8% were high school students. A mere 19.2% (n=397) of the participants had previously engaged in a model-eliciting activity.

Procedure

Since mathematics teachers generally do not prefer doing mathematical model-eliciting activities in the classroom (Bilgili & Çiltaş, 2019; Blum & Borromeo Ferri, 2009), it was assumed that the students participating in this study did not have much experience with model-eliciting activities. The model-eliciting activities named Straw Bails (Borromeo Ferri, 2007) and Sultan Kösen (Tekin Dede, 2015) were implemented the students with an interval of one week (see Figure 2). Although these model-eliciting activities were developed for middle school level, since high school students are inexperienced in modelling, they can also be applied to high school students.

At the end of the summer, one can see many straw bails. Straw bails in the picture are piled up this way: the bottom line is five, in the next four, then three, then two, and on the top one ball. Try to find out exactly how high this mountain of straw bails is.

Born in Mardin on 10 December 1982, Sultan Kösen is the tallest living person in the world, according to the Guinness Book of Records. He is 2 metres 51 cm tall.

He also has the "biggest hands" (27.5 cm) and the "biggest feet" (36.5 cm).

What size shoes does Sultan Kösen, whose height, hand, and foot lengths are given above, wear?

Figure 2. Model-eliciting activities

One week after the implementation of the model-eliciting activities, the "Mathematical Modeling Self-Efficacy Scale [MMSS]" developed by Koyuncu et al. (2017) was implemented to determine students' beliefs about their competence in mathematical modeling. The scale consists of 17 items and is one-dimensional and five-point Likert type. The scores to be obtained from the scale vary between 17 and 85 points. A linear relationship exists between the score obtained from the scale and the mathematical modeling self-efficacy belief. Therefore, the higher the score obtained from the scale, the higher the mathematical modeling self-efficacy belief will be.

Data analysis

Koyuncu et al. (2013) documented a Cronbach's alpha coefficient of the MMSS of .91 for pre-service mathematics teachers, and Yıldız and Yetim (2024) reported a Cronbach's alpha coefficient of the MMSS of .89 for middle school students. In the present study, Cronbach's alpha coefficients for the MMSS were .89 for middle school, .90 for high school, and .90 for the entire group. Therefore, the MMSS proved to be a valid and reliable instrument for assessing the mathematical modeling self-efficacy beliefs of both middle and high school students.

In the initial analysis, the distributions of the variables were tested for normality using skewness and kurtosis (values greater than ± 1 and $p > .05$). It was found that the test scores met the criteria for a normal distribution of the variables (Tabachnick et al., 2013). Subsequently, t-tests and ANOVA test statistics were used to assess the effect of the independent variables on the dependent variables (George & Mallery, 2010). Ranges were calculated to make the mean of the total scores obtained from the scale meaningful. The ranges and indicators in the study conducted by Erdoğan (2019), in which the MMSS was implemented to the pre-service teachers, were used in the present study (see Table 2).

Table 2. Ranges and indicators in the scale

Ranges	Indicators
1.00-1.79	strongly disagree
1.80-2.59	disagree
2.60-3.39	undecided
3.40-4.19	agree
4.20-5.00	strongly agree

Results

Descriptive statistics related to the mathematical modeling self-efficacy beliefs of middle and high school students are presented in Table 3.

Table 3. Descriptive statistics of the MMSS scale

Variable	Answers	N	$\bar{X}$	s.d	Level
Gender	Female	1091	3.24	.024	Medium
	Male	974	3.25	.025	Medium
School Level	Middle School	1077	3.29	.029	Medium
	High School	988	3.20	.026	Medium
Grade Level	6^{th} Grade	294	3.28	.043	Medium
	7^{th} Grade	483	3.34	.034	Medium
	8^{th} Grade	300	3.20	.046	Medium
	9^{th} Grade	218	3.23	.055	Medium
	10^{th} Grade	180	3.13	.062	Medium
	11^{th} Grade	590	3.21	.034	Medium
Previous engagement in model-eliciting activities	Yes	397	3.40	.039	High
	No	1668	3.21	.019	Medium
Total		2065	3.24	.017	Medium

The means of the participants' MMSS scores are close to each other according to gender, school level, and grade level (see Table 3). According to these variables, the participants' mathematical modeling self-efficacy beliefs are at a medium level (undecided). Moreover, the modeling self-efficacy beliefs of the participants who have previously engaged in model-eliciting activities are at a high level (strongly agree), and the modeling self-efficacy beliefs of the participants who had not previously engaged in model-eliciting activities are at a medium level (undecided).

Table 4. Independent samples t-test results comparing middle and high school students

		N	$\bar{X}$	s.d.	df	t	p
School level	Middle School	1077	3.29	.029	2063	2.448	.014*
	High School	988	3.20	.026			

* p< .05

There is a statistically significant difference between the MMSS means of the participants in terms of school level [t(2063)= 2.448; p< .05] (see Table 4). Thus, the mathematical modeling self-efficacy beliefs of the middle school students ($\bar{X}$=3.29) are higher than those of the high school students ($\bar{X}$=3.20). This indicates a significant difference in MMSS means between middle and high school students with a small effect size (eta squared = 0.003) (Richardson, 2011). The fact that high school education is based less on hands-on problem-solving and more on lectures may reduce students' self-efficacy in practical applications such as mathematical modeling.

Table 5. ANOVA results by grade level variable

		Sum of Squares	df	Mean Square	F	p	Significant Difference
Middle School	Between Groups	3.629	2	1.814	3.056	.047*	$7^{th} – 8^{th}$
	Within Groups	637.652	1074	.594			
	Total	641.281	1076				
High School	Between Groups	1.087	2	2.669	.783	.457	-
	Within Groups	683.924	985	.505			
	Total	685.011	987				

* p< .05

A statistically significant difference is found between the MMSS means of the middle school students in different grade levels [$F(2,1074)= 3.056$, $p< .05$] (see Table 5). According to the Tukey test, which was performed to find out which groups the mean scores of the MMSS scale differ between the different grades, the mathematical modeling self-efficacy beliefs of the seventh-grade students ($\bar{X}$ =3.24) are higher than those of the eighth-grade students ($\bar{X}$=3.20). Additionally, there is no statistically significant difference between the MMSS means for the grade levels of the high school students [$F(2,985)= .783$, $p> .05$]. Accordingly, high school students' mathematical modeling self-efficacy beliefs are generally the same across grade levels.

Table 6. Independent samples t-test results comparing males and females

		N	$\bar{X}$	s.d.	df	t	p
Middle School	Female	569	3.33	.790	1075	1.890	.059
	Male	508	3.24	.749			
High School	Female	522	3.14	.818	986	-2.267	.024*
	Male	466	3.26	.845			

* p< .05

No statistically significant difference is found when comparing the middle school students' MMSS means according to gender [$t(1075) = 1.890$; $p> .05$] (see Table 6). This result shows that gender does not affect middle school students' mathematical modeling self-efficacy beliefs. On the other hand, the mathematical modeling self-efficacy beliefs of male high school students ($\bar{X}$=3.26) are higher than those of female high school students ($\bar{X}$=3.14). Furthermore, there is a significant difference between the MMSS means of the high school students in terms of gender [$t(986) = -2.267$; $p< .05$]. This indicates a significant difference in MMSS means between male and female high school students with a small effect size (eta squared = 0.005) (Richardson, 2011). Male high school students' self-efficacy may be higher if they are more often exposed to or praised for their mathematical abilities, while female high school students may feel less competent compared to their male peers. Furthermore, the educational environment itself in high schools might unintentionally favor males, possibly through the types of examples used, interaction patterns in the classroom, or the differential encouragement given by teachers to students based on gender.

Table 7. Independent samples t-test results for previous engagement in a model-eliciting activity

		N	$\bar{X}$	s.d.	df	t	p
Middle School	Yes	227	3.44	.766	1075	3.482	.001*
	No	850	3.24	.768			
High School	Yes	170	3.34	.833	986	.917	.018*
	No	818	3.17	.830			

* p< .05

There is a significant difference between the MMSS means of the middle school students in terms of previous engagement in a model-eliciting activity [$t(1075) = 3.482$; $p< .05$] with a small effect size (eta squared = 0.011) (Richardson, 2011) (see Table 7). Accordingly, the mathematical modeling self-efficacy beliefs of middle school students who have previously engaged in a model-eliciting activity ($\bar{X}$=3.44) are higher than those of middle school students who have not previously engaged in a model-eliciting activity ($\bar{X}$=3.24). Similarly, there is a significant difference between the MMSS means of the high school students concerning previous engagement in a model-eliciting activity [$t(986) = .917$; $p< .05$] with a small effect size (eta squared = 0.001) (Richardson, 2011). Thus, the mathematical modeling self-efficacy beliefs of high school students who have previously engaged in a model-eliciting activity

($\overline{X}$=3.34) are higher than those of high school students who have not previously engaged in a model-eliciting activity ($\overline{X}$=3.17).

Discussion and Conclusion

This study aimed to investigate the mathematical modeling self-efficacy beliefs of middle and high school students and whether their mathematical modeling self-efficacy beliefs differ in school level, grade level, gender, and previous engagement in model-eliciting activities. As there are no studies in the available literature that examine the mathematical modeling self-efficacy beliefs of middle and high school students, the results of the study will be compared with studies conducted with different participants that focus on mathematics self-efficacy.

The results revealed that the participants' mathematical modeling self-efficacy beliefs were at a medium level (undecided) according to school level, grade level, and gender. This implies that the mathematical modeling self-efficacy beliefs of middle and high school students are not at the desired level and should be improved. In the studies conducted with pre-service teachers (Erdoğan, 2019; Siller & Kuntze, 2011), the participants' mathematical modeling self-efficacy beliefs were found to be at a medium level (undecided), supporting this study's results. This is because a positive relationship exists between students' mathematical modeling self-efficacy beliefs and their mathematical modeling skills (Kelly, 2014; Smith et al., 1994). Students may not have had sufficient exposure to mathematical modelling early in their education. Without regular practice and engagement, students may not have developed the skills needed to feel up to par in mathematical modelling. Furthermore, students' perception of mathematical modelling as abstract and disconnected from other learning experiences may hinder their understanding and reduce their self-efficacy.

The mathematical modeling self-efficacy beliefs of the middle school students ($\overline{X}$=3.29) were higher than those of the high school students ($\overline{X}$=3.20). Research shows that although students' perceptions of lessons such as mathematics, science, and technology are perfect, there is a decrease in these perceptions as grade level increases (Potvin & Hasni, 2014). Middle school students' higher self-efficacy may be due to a confidence that has not yet been challenged by the more complex and abstract mathematical concepts introduced in high school. As students progress into high school, the mathematical problems they encounter become significantly more complex and demanding. The increased difficulty can lead to a decrease in self-efficacy as students realize the gaps in their knowledge and skills. Therefore, the higher mathematical modeling self-efficacy of middle school students compared to high school students can be explained by the fact that students perceive difficulties in high school mathematics classes compared to middle school classes, and thus, their beliefs that they can do mathematical modeling decrease.

In this study, the mathematical modeling self-efficacy beliefs of the seventh-grade students ($\overline{X}$= =3.24) were higher than those of eighth-grade students ($\overline{X}$=3.20). This result is consistent with that of Adal and Yavuz (2017), who found that the mathematics self-efficacy of eighth-grade students was lower than that of seventh-grade students. The fact that eighth-grade students began to feel more mathematics pressure due to the high school entrance exam may have decreased their mathematics self-efficacy. On the other hand, mathematical modeling self-efficacy beliefs of high school students were generally the same across grades in this study. This result reflects that of Uzar (2010), who found that mathematics self-efficacy did not differ by grade level. Self-efficacy is an essential factor in the mathematical modeling learning process (Holenstein et al., 2022), and the fact that most students have not engaged in model-eliciting activities may not have differentiated their mathematical modeling self-efficacy.

In the literature, there are studies in which mathematics self-efficacy differs and does not differ according to gender (Cooper & Robinson, 1991; Hacket & Betz, 1989; Işıksal & Aşkar, 2003; Pajares & Kranzler, 1995; Pajares & Miller, 1997). Some of the studies (Hacıömeroğlu & Elmalı, 2021; Işıksal & Aşkar, 2003) did not find any gender difference in mathematics self-efficacy at the middle school level. Similarly, in the present study, the gender variable did not affect students' mathematical modeling self-efficacy beliefs. Moreover, this result seems consistent with other studies that found no statistically significant difference in the mathematical modeling self-efficacy beliefs of pre-service elementary mathematics teachers concerning gender (Erdoğan, 2019). In the studies where mathematics self-efficacy differed according to gender, the difference was in favor of males, and the result of this study supports this result, as the mathematical modeling self-efficacy beliefs of male high school students ($\overline{X}$=3.26) were higher than those of female high school students ($\overline{X}$=3.14). Pajares (2005), Pajares and Miller (1997), and Tella (2011) also found that the mathematical modeling self-efficacy of males was higher than that of females at the high school level.

One of the remarkable results of this study was that the mathematical modeling self-efficacy beliefs of the students who had previously engaged in mathematical model-eliciting activities were statistically higher than those of the students who had not. In fact, at both middle and high school levels, the mathematical modeling self-efficacy beliefs of the students who had previously been exposed to model-eliciting activities were higher than those who had not. Self-efficacy is an individual's internal beliefs about what they can do with their skills (Bandura, 1997). Therefore, the increased internal beliefs of the students exposed to model-eliciting activities may have increased their mathematical modeling self-efficacy. In this context, solving model-eliciting activities can increase mathematical modeling self-efficacy beliefs. Students' mathematical modeling self-efficacy beliefs are not high enough, so they should be exposed to more model-eliciting activities to strengthen their mathematical modeling self-efficacy beliefs (Smith et al., 1994). Several research studies investigating the solution process of mathematical model-eliciting activities also underscored that students should be exposed to more model-eliciting activities (Albayrak & Tarım, 2022; Karahan & Ergene, 2023; Uzun et al., 2023).

In the available literature, no study has investigated and compared the mathematical modeling self-efficacy beliefs of middle and high school students simultaneously. Therefore, the results of this study can contribute to the literature on mathematical modeling. Furthermore, the fact that the research was conducted with a large number of participants was a strong aspect of this study. On the other hand, the fact that students' ability to use their mathematical knowledge in mathematical modeling and problem-solving and their mathematics self-efficacy change with mathematics education at schools should not be ignored (NCTM, 2000). For this reason, the results of this study on the mathematical modeling self-efficacy beliefs of middle and high school students may need to be considered together with the process of teaching and learning mathematics. In addition, intervention studies should be conducted to increase students' mathematical modeling self-efficacy beliefs.

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