The Relationship Between Teacher Candidates' Competence in Designing Model-Elicting Activity, Problem-Solving and Problem-Posing Beliefs

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Absract

This study aimed to determine the change and the relationship between elementary school mathematics teacher candidates' competence to design model-eliciting activities, problem-solving and problem-posing beliefs according to gender and overall academic grade point average (GPA). Modeling activities designed by 64 elementary school mathematics teacher candidates in Turkey were evaluated by means of a grading key created in the context of "compliance with MEA design principles". In addition, a scale consisting of 24 items was applied to determine the beliefs of the teacher candidates towards problem-solving, and a 26-item scale was applied to determine their self-efficacy beliefs towards problem-posing, and the responses were analyzed by quantitative methods (one-way multiple variance analysis, correlation analysis, multiple regression test). The findings reveal that elementary school mathematics teacher candidates' proficiency in designing model-eliciting activities is generally at a high level, while their belief in problem-solving and self-efficacy beliefs in problem posing is generally at a moderate level. It was determined that the linear combinations of teacher candidates' proficiency in designing model-eliciting activities, beliefs in problem-solving, and self-efficacy beliefs in problem-posing did not show a significant difference. However, it was determined that there was a positive and moderately significant relationship between teacher candidates' beliefs towards problem solving and self-efficacy beliefs towards problem posing. Teacher candidates had a high level of competence in designing MEA, it was determined that this situation was not related to their problem-solving and problem-posing beliefs. However, since the mathematical modeling process is basically considered as a problem-solving process, it was expected that these beliefs mathematics teacher candidates would be related to MEA design competence. In order to examine this situation in more detail and to reveal the underlying reasons, it is recommended to conduct qualitative research with teacher candidates.

Keywords: *Model-eliciting activities, Problem-solving belief, Problem-posing belief, Mathematics teacher candidates, Mathematical modeling*

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INTRODUCTION

Mathematical modeling is an area in mathematics teaching and that aims to enable students to acquire the modeling skills necessary for solving real life problems. The ability of students to use these skills has also taken its place among the special skills that students should acquire. In order to explain the concept of mathematical modeling, the concept of model should be introduced first. Although there are many definitions of modeling, in the Common Core Standards (2010) modeling is defined as a standard for mathematical practices that teachers should try to develop in students. Thus is considered a process that enables them to access and use existing mathematical knowledge in solving real life problems. The main purpose of mathematical modeling is to make sense of a real-life problem using mathematics and to find a suitable solution for it (Dogan, Ozaltun-Celik & Bukova-Guzel, 2021).

To better express the features of mathematical modeling, we can compare mathematical modeling with mathematical problem-solving. Mathematical modeling starts with real situations and then returns to those states. Mathematical problem-solving involves both real-world situations and theoretical mathematical problems (Kim, 2012; Pollak, 2012). Mathematical problem-solving and modeling often refer to the real world, but mathematical problem solving is more likely to be done in an idealized way than the real world as it is. Mathematical problem-solving can have theoretical and applied mathematical problems, but mathematical modeling is mainly used to apply mathematics in everyday life (Blum & Niss, 1991). This also helps students to interpret mathematics in the context of daily life and to understand where the abstract concepts and formulas learned can benefit them. Therefore, it is essential to learn and make sense of mathematical concepts, formulas, graphics, etc., and mathematical tools before proceeding to the mathematical modeling process. Lesh and Zawojewski (2007) argue that mathematical modeling should be used to teach mathematics to students who are expected to solve mathematical problems, after learning mathematical concepts and formulas. Considering that transferring abstract mathematical concepts to the concrete world is not an easy process, mathematical modeling includes tasks that require advanced cognitive skills, while mathematical problem-solving includes tasks that require different cognitive skills.

Although mathematical modeling and problem-solving differ in their intensities to include cognitive skills, Lesh and Doerr (2003) see mathematical modeling as problem-solving activities and argue that these activities enable individuals to understand mathematical concepts, relationships, and behaviors in the problem-solving process. As Pollak (2012) and Han and Kim (2020) stated, mathematical modeling includes not only the problem-solving phase but also the problem-discovery phase from the real situation. From this point of view, problem posing, which can be considered the discovery of a mathematical problem, can be accepted as a skill that mathematical modeling contains and can emerge in the process.

Since problem-posing is closely related to problem-solving and the two skills have aspects that improve each other, problem-posing and problem-solving are often mentioned together (Bonotto & Dal Santo, 2015; Cai, 1998; Cai & Hwang, 2002; Chen et al., 2015; Cai et al., 2015; Silver & Cai, 1996). Problem-solving in math education usually means creating new problems or restructuring existing problems. In particular, the restructuring of an existing problem is done by changing the context or some information to reach a solution in the problem-solving process (Silver, 1994). The emphasis on contextual knowledge in problem-posing is similarly found in mathematical modeling. In this process, students are expected to interpret the data in real life depending on the given context, to use this real-life context for the solution, and then to generalize the solution by revising it in real life. In this regard, in mathematical modeling, which is an advanced problem-solving process, it can be expected that problem-solving and problem-posing will take place in the process in a related way. According to Kula-Unver et al. (2018) posing a modelling problem is influenced by both the person's modelling perspective and the experience of problem posing. In this context, studies examined modelling and problem posing are also important.

Teachers are the most significant factor influencing the successful realization of mathematical modeling practices. The role of teachers in the mathematical modeling process and the pedagogical knowledge and skills they should have are different (Doerr, 2006; 2007). Borromeo-Ferri (2014) discussed that one of the pedagogical knowledge and competencies that teachers should have in mathematical modeling, the teacher should know the characteristics of a good modeling activity, learn to make cognitive analyzes of modeling activities, and develop modeling activities in a group. It has been determined that teachers may experience limitations in reaching these competencies of mathematical modeling due to their lack of experience and beliefs (Borromeo-Ferri, 2011; Ng, 2013; Stillman, 2019). Kaiser and Maaß (2007) also stated that one of the reasons why mathematical modeling is not included in mathematics teaching at the desired level is that the beliefs in mathematics teaching prevent such practices. Since mathematical modeling has a positive effect on students' metacognitive thinking skills and the role of the teacher is important in improving these skills (Brady, 2018; Lowe, Carter & Cooper, 2018), determining teachers' beliefs and self-efficacy about mathematical modeling is essential in terms of their performance in the mathematical modeling process used in the learning environment (Koyuncu, Guzeller & Akyuz, 2017). Teachers' self-efficacy is expected to be high because effective teaching is associated with teachers' self-efficacy (Schunk & Pajares, 2009). Mathematics teachers who have high self-efficacy beliefs are the key to the realization of mathematics teaching at the desired level. Considering that the development of self-efficacy belief begins in the pre-professional period, it is thought that determining the self-efficacy of future mathematics teachers about certain fields (mathematics, mathematical modeling, mathematical literacy, etc.) is an important issue that needs to be studied.

Model-eliciting activities that are frequently used in the learning process in mathematical modeling are non-routine modeling activities that are defined to have specific principles and components. Each model-eliciting activity requires students to mathematically interpret a complex situation in real life and create a mathematical definition, process, and method to assist a person who consults them (Mousoulides & English, 2008; Lesh & Zawojewski, 2007). This process has a structure that includes six principles (English et al., 2008; Kelly, Lesh & Baec, 2008). These principles are the reality principle, model construction principle, self-assessment principle, construct documentation principle, construct shareability and reusability principle, and effective prototype principle. These six principles aim to increase the level of revealing students' thoughts in the activities developed, and the efficiency and quality of model-eliciting activities (Doruk, 2019). Thus, it can be considered that teacher candidates who can design a model-eliciting activity with these principles have competence in this field. Therefore, it was decided to evaluate the teacher candidates' competence in designing model-eliciting activities according to the scores they received from the grading key prepared by Doruk (2019), which includes these principles.

It was accepted that teacher candidates who received training in mathematical modeling, and problem-solving, had both problem-solving and problem-posing knowledge and skills in the process of designing model-eliciting activities. In this regard, this study aimed to determine the change and the relationship between elementary school mathematics teacher candidates' competence to design MEAs, their beliefs towards problem-solving, and their self-efficacy beliefs towards problem posing according to gender and overall academic grade point average (GPA). For this purpose, answers to the following questions were sought.

1. What is the level of elementary school mathematics teacher candidates' competencies in designing MEA, their beliefs about problem-solving, and self-efficacy beliefs about problem-posing?
2. Do elementary school mathematics teacher candidates' competencies to design MEA, their beliefs towards problem-solving, and their self-efficacy beliefs towards problem-posing differ according to their academic achievements?
3. Are elementary school mathematics teacher candidates' beliefs about problem-solving and self-efficacy beliefs about problem posing a significant predictor of their MEA design competencies?

METHOD

Research Design

The mixed method was used in this study, which aimed to reveal the elementary school mathematics teacher candidates' competencies to design MEA, their beliefs towards problem-solving, self-efficacy beliefs towards problem-posing, and the relationship between them. The mixed method focuses on the collection, analysis, and collation of both qualitative and quantitative data in a single study or research sequence. Its main premise is the combined use of qualitative and quantitative data, providing a much better understanding of the research problem than any method used alone (Creswell & Plano Clark, 2007). The research problem and the importance of the research questions are the key principles for the mixed-method research design. In this study, first of all, the competence of teacher candidates to design MEAs was determined as a problem. Therefore, the research process started with the collection of qualitative data. Then, considering that the teacher candidates went through the problem-posing and solving processes while designing the MEAs, it was questioned to what extent the teacher candidates' beliefs about these skills were and whether there was a relationship between these components. Thus, the quantitative data collection process to determine these beliefs was continued. In this regard, a nested mixed pattern was used in the study. This design is a mixed method approach in which the researcher brings together the study and analyzes qualitative and quantitative data within the framework of traditional qualitative or quantitative research designs (Caracelli & Greene, 1997; Greene, 2007). The purpose of this pattern is to collect and analyze complementary data in situations where different questions need to be answered. This pattern was adopted because it was suitable for the structure of the study. Thus, MEA design competencies, problem-solving beliefs, and problem-posing self-efficacy beliefs were measured without any effect on the variables, the relationships between them were determined, and based on these relationships, the relationship between participants' belief in problem-solving and self-efficacy beliefs in problem posing and competence in designing MEAs were examined.

Sample of the Study

The sample of the study consists of 64 teacher candidates studying in the primary school mathematics teacher education program. The criterion sampling method, one of the purposeful sampling methods, was used in the selection of samples. In criterion sampling, the sample that meets the criteria determined for a situation to be studied is selected. Here, criteria are determined to represent the purpose of the study (Yildirim & Simsek, 2011). In accordance with the purpose of this study, taking the "Problem-Solving Approaches in Mathematics" and "Mathematical Modeling" courses was determined as criteria. In this regard, teacher candidates studying in the fourth grade formed the sample of the study.

Data Collection Tools

Model Elicting Activities: In the study, first of all, each of the participants was asked to design an MEA. It was requested that the MEAs to be designed should include the achievements in five different learning areas in the elementary school mathematics curriculum. Thus, it is aimed to increase the competence of students to design modeling activities in each learning area. Students are given a total of 4 weeks to design an MEA. During this process, students created MEAs according to the gains/achievements in their chosen learning area, then applied them to elementary school students as a pilot application and finalized their activities in line with the feedback received (see Appendix 1). An example of MEAs created by teacher candidates is given in the Appendix 2. In the prepared MEA, the outcome of " Solves area-related problems (Problems that require finding the areas of compound shapes consisting of triangle, rectangle, parallelogram, trapezoid or rhombus are included.)." is based. To evaluate the suitability of the designed MEAs, the "Criteria for Agreement to MEA Design Principles" developed by Doruk (2019) was used. Thus, the competence of teacher candidates to design MEA was determined. The relevant form has been prepared to determine the levels of providing the principles of MEA design. The form includes a total of 19 criteria: 5 for the model creation principle, 4 for the reality principle, 2 for the model generalization principle, 3 for the effective prototype principle, 2 for the model documentation principle, and 3 for the self-evaluation principle. While examining the compliance of any activity with the MEA design principles through this form, failure to meet a criterion is represented by 0, partially provided by 1, and fully provided by 2. Thus, it is aimed to facilitate the digitization of the qualitative findings obtained as a result of the examination of any activity by researchers (Doruk, 2019). The lowest score that can be obtained from the scale is 0 and the highest score is 38.

Beliefs About Mathematical Problem Solving Instrument: The 5-point Likert-type "Beliefs About Mathematical Problem Solving Instrument" developed by Kloosterman and Stage (1992) and adapted to Turkish by Haciomeroglu (2011) was used to determine efficacy beliefs towards problem-solving. As a result of the validity and reliability studies of the scale, it was determined that 24 of the 36 items in the original version could be used in the Turkish adaptation. It was determined that the factors in the scale also differed from the original version. Five factors were determined on the adapted scale. There are a total of 24 items on the scale, including 6 items in the "Mathematical Skill" factor, 6 items in the "Place of Mathematics" factor, 5 items in the "Understanding the Problem" factor, 3 items in the "Importance of Mathematics" factor, and 4 items in the "Problem-Solving Skill" factor. In the adapted form of the scale, Cronbach's alpha internal consistency coefficient was calculated as 0.768. In this study, the reliability coefficient was calculated as 0.785 and it was determined that the scale was reliable.

Teachers' Problem Posing Self Efficacy Beliefs Scale: The 5-point Likert-type "Teachers' Problem Posing Self Efficacy Beliefs Scale" developed by Kilic and Incikabi (2013) was used to determine self-efficacy beliefs for problem posing. There are 3 factors on the scale: "Teaching Competence", "Effective Teaching Competence" and "Field Knowledge Competence". There are a total of 26 items, including 9 items in the first factor, 9 items in the second factor, and 8 items in the third factor. The Cronbach's alpha internal consistency coefficient of the scale was calculated as 0.912. In this study, the internal consistency coefficient was calculated as 0.835.

Data Analysis

Regarding the first research question, MEAs designed by teacher candidates were evaluated using the "Criteria for Agreement to MEA Design Principles" developed by Doruk (2019) to determine the competencies of participants in designing MEAs. While examining the compliance of any activity with the MEA design principles through this form, failure to meet a criterion is represented by 0, partially provided by 1, and fully provided by 2. The lowest score that can be obtained from the scale is 0 and the highest score is 38. To reveal the teacher candidates' competency in designing the MEA, the form was divided into three levels, dividing the interval for each item into three equal parts, 0-0.666 as low, 0.667-1.333 as moderate, and 1.334-2 as high. To reveal the levels of beliefs about problem-solving and self-efficacy beliefs for problem-posing, the five-point Likert-type scale was divided into three levels, dividing the interval for each item into three equal parts, as 1-2.333 low, 2.334-3.666 moderate, and 3.667–5 high. These limits were multiplied by the number of items in the form and scale and limits were determined as low-level, moderate-level, and high-level according to the sum that the participants received from the scale. The limits determined according to each variable are presented in Table 1.

Table 1. *Score levels of MEA design competencies, problem-solving beliefs, and problem-posing self-efficacy beliefs*

Levels	MEA design competencies score	Problem-solving belief score	Problem-posing self-efficacy belief score
Low level	0-12.7	24-56	26-60.7
Moderate level	12.8-25.3	56.1-88	60.8-95.3
High level	25.4-38	88.1-120	95.4-130

Based on the score ranges presented in Table 1, the distribution of the participants was determined.

The total score obtained from the form was accepted as a quantitative value indicating the competence of the teacher candidates to design MEAs. Three different researchers participated in the evaluation process and the percentage of agreement was determined as 92%. A consensus was reached on the final score given to the activity, and the process was completed.

Regarding the second research question, a one-way MANOVA test was used to determine whether there was a significant difference between the teacher candidates' competencies to design MEA, their beliefs towards problem-solving, and their self-efficacy beliefs towards problem-posing according to their academic achievements. Because there are three dependent variables: competencies in designing MEAs, beliefs in problem-solving, and self-efficacy beliefs in problem-posing. Regarding the third research question, multiple regression tests were used to analyze whether the teacher candidates' beliefs towards problem-solving and their self-efficacy beliefs towards problem-posing are significant predictors of their competencies in designing MEAs.

FINDINGS

In this section, the findings regarding each research question will be discussed respectively.

1- ***Findings regarding the first research question: "What is the level of elementary school mathematics teacher candidates' competencies in designing MEA, their beliefs about problem-solving, and self-efficacy beliefs about problem-posing?"***

The distribution of mathematics teacher candidates according to their MEAs design competencies is given in Figure 1.

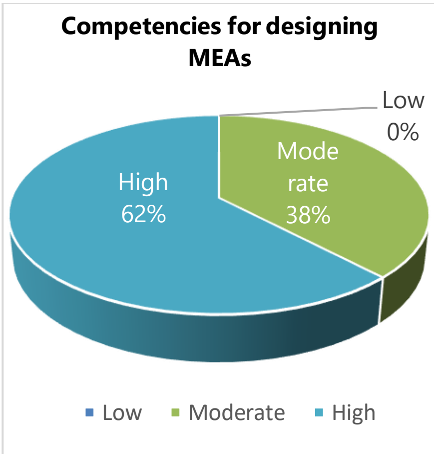

Figure 1. *Distribution of participants' levels of competence in designing MEAs*

According to Figure 1, it was determined that 62% of the participants had a high level of competence in designing MEAs and 38% had a medium level of competence. In other words, 62% of the participants scored between 25.4 and 38 for the MEAs design competence, while 38% scored between 12.8 and 25.3 for the design competence. There is no participant with a low score (0-12,7).

The distribution of mathematics teacher candidates according to their their beliefs towards problem-solving is given in Figure 2.

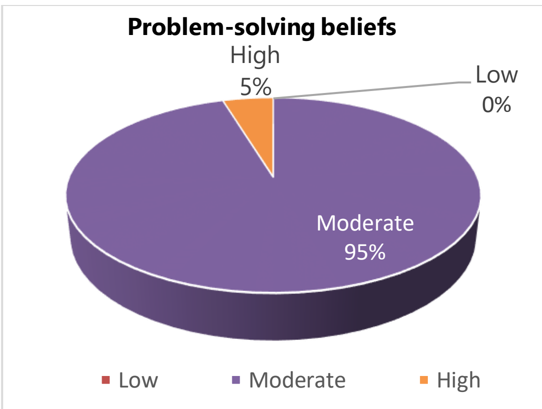

Figure 2. *Distribution of participants' beliefs towards problem-solving*

According to Figure 2, it was determined that 5% of the participants had a high level of beliefs towards problem-solving and 95% had a medium level of beliefs. In other words, 5% of the participants

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scored between 25.4 and 38 for beliefs towards problem-solving, while 95% scored between 12.8 and 25.3 for beliefs towards problem-solving. There is no participant with a low score (0-12.7) for problem-solving beliefs.

The distribution of mathematics teacher candidates according to their their self-efficacy beliefs towards problem-posing is given in Figure 3.

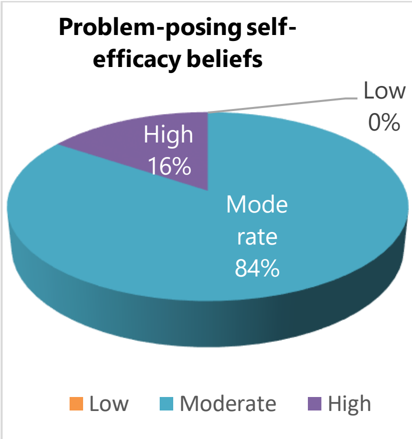

Figure 3. *Distribution of participants' self-efficacy beliefs towards problem-posing*

According to Figure 3, it was determined that 16% of the participants had a high level of self-efficacy beliefs towards problem-posing and 84% had a medium level of self-efficacy beliefs. In other words, 16% of the participants scored between 25.4 and 38 for self-efficacy beliefs towards problem-posing, while 84% scored between 12.8 and 25.3 for self-efficacy beliefs towards problem-posing. There is no participant with a low score (0-12.7) for problem-posing self-efficacy beliefs.

According to these findings, it was determined that the participants showed higher performance than the others (beliefs towards problem-solving and self-efficacy beliefs towards problem-posing) at the level of MLE design competences. It is seen that their self-efficacy beliefs towards problem posing are at a better level than their beliefs towards problem-solving.

Table 2 shows the distribution of pre-service mathematics teachers' MEA design competencies, problem-solving beliefs, and problem-posing self-efficacy beliefs according to their academic achievements.

Table 2. *Mean and standard deviation of pre-service teachers' MEA design competencies, problem-solving beliefs, and problem-posing self-efficacy beliefs according to their academic achievements*

	Academic success status	Mean	Standard deviation	N
Competencies for designing MEA	0-1.99	23.50	7.204	6
	2.00-2.49	26.88	6.972	9
	2.50-2.99	28.56	6.577	23
	3.00-3.49	29.33	4.453	21
	3.50-4.00	32.40	5.079	5
	Total	**28.40**	**6.124**	**64**
Beliefs towards problem-solving	0-1.99	80.33	2.250	6
	2.00-2.49	77.88	3.982	9
	2.50-2.99	80.21	5.648	23
	3.00-3.49	80.71	5.139	21
	3.50-4.00	81.40	4.393	5
	Total	**80.15**	**4.912**	**64**
Self-efficacy beliefs towards problem-posing	0-1.99	92.16	4.665	6
	2.00-2.49	87.77	4.944	9
	2.50-2.99	90.21	6.619	23
	3.00-3.49	90.23	6.796	21
	3.50-4.00	89.00	4.415	5
	Total	**89.96**	**6.107**	**64**

As can be seen in Table 2, pre-service teachers' MEA design competency, problem-solving belief, and problem-posing self-efficacy belief mean scores according to their academic achievements are close.

2- ***Findings regarding the second research question: "Do elementary school mathematics teacher candidates' competencies to design MEA, their beliefs towards problem-solving, and their self-efficacy beliefs towards problem-posing differ according to their academic achievements?"***

A one-way MANOVA test was used to determine whether teacher candidates' MEA design competencies, problem-solving beliefs, and problem-posing self-efficacy beliefs differ according to their academic success. Table 3 shows the MANOVA test results on how teacher candidates' competencies in designing MEAs, their beliefs towards problem-solving, and their self-efficacy beliefs towards problem-posing change according to their academic achievements.

Table 3. *A relationship between teacher candidates' competence in designing MEAs, their beliefs towards problem-solving and their self-efficacy beliefs towards problem-posing, and their academic success*

	Academic success status	N	$\bar{X}$	Sd	Sd	F	p	n^2
Competencies for designing MEA	0-1.99	6	23.50	7.20	4	1.851	.131	.112
	2.00-2.49	9	26.88	6.97				
	2.50-2.99	23	28.56	6.57				
	3.00-3.49	21	29.33	4.45				
	3.50-4.00	5	32.40	5.07				
Beliefs towards problem-solving	0-1.99	6	80.33	2.25	4	.651	.654	.040
	2.00-2.49	9	77.88	3.98				
	2.50-2.99	23	80.21	5.64				
	3.00-3.49	21	80.71	5.13				
	3.50-4.00	5	81.40	4.39				
Self-efficacy beliefs towards problem-posing	0-1.99	6	92.16	4.66	4	.519	.722	.034
	2.00-2.49	9	87.77	4.94				
	2.50-2.99	23	90.21	6.61				
	3.00-3.49	21	90.23	6.79				
	3.50-4.00	5	89.00	4.41				

According to Box's M statistic, which is a parametric test used to compare the variances of multivariate samples, the homogeneity assumption of the spread matrix was not provided ($F = 1.710$, $p = .18$). Therefore, the results of the Pillai Trace test were interpreted instead of Wilk's Lambda value. The results of the Pillai Trace test revealed that the linear combinations of teacher candidates' competence to design MEAs, their beliefs towards problem-solving, and their self-efficacy beliefs towards problem-posing did not show a significant difference in terms of academic success (Pillai Trace $\lambda = 0.163$, $F = .848$, $p = .601$). When the results of the teacher candidates' MEA design competencies and the academic achievement variable were examined, it was determined that there is no significant difference ($F = 1.851$, $p > .01$). In the same table, it can be seen that the beliefs of the teacher candidates towards problem-solving do not show a significant difference according to their academic success ($F = .615$, $p > .01$). Similarly, it was determined that the self-efficacy beliefs of the teacher candidates towards problem-posing do not differ significantly according to their academic success ($F = .519$, $p > .01$).

3- ***Findings regarding the third research question: "Are elementary school mathematics teacher candidates' beliefs about problem-solving and self-efficacy beliefs about problem posing a significant predictor of their MEA design competencies?"***

Firstly correlation analysis and then multiple regression analyzes were used to test whether middle school mathematics teacher candidates' beliefs towards problem-solving and self-efficacy beliefs towards problem-posing are significant predictors of their MEA design competencies. Table 4 shows the correlation results, and Table 5 shows the regression results.

Table 4. *Results of correlation analysis between beliefs towards problem-solving, self-efficacy beliefs towards problem-posing, and competence to design MEAs*

		Beliefs towards problem-solving	Self-efficacy beliefs towards problem-posing	Competencies for designing MEA
Beliefs towards problem-solving	Pearson Correlation	1		
	p			
	N			
Self-efficacy beliefs towards problem-posing	Pearson Correlation	.442**	1	
	p	.000		
	N	64		
Competencies for designing MEA	Pearson Correlation	.195	.105	1
	p	.122	.407	
	N	64	64	

As a result of Pearson correlation analysis, it was found that there was a positive and moderately significant relationship (r = .442, p < .01) between beliefs towards problem-solving and self-efficacy beliefs toward problem-posing. On the other hand, it was determined that there was no significant relationship between MEA design competencies and beliefs toward problem-solving and self-efficacy beliefs toward problem-posing (r = .195, r = .105, p > .01).

Table 5 shows the results of multiple linear regression analysis.

Table 5. *Results of regression analysis on prediction of MEA competencies*

Variables	B	Standard Error	Beta	t	p
Constant	39.232	27.239		1.440	.155
Beliefs towards problem-solving	.491	.372	.185	1.322	.191
Self-efficacy beliefs towards problem-posing	.024	.140	.024	.170	.866

As can be seen in Table 5, it was determined that problem-solving beliefs ($\beta = .185, p > .05$) and problem-posing self-efficacy beliefs ($\beta = .024, p > .05$) were not significant predictors of MEA competencies.

CONCLUSION, DISCUSSION AND RECOMMENDATIONS

In this study, the competencies of elementary school mathematics teacher candidates to design MEAs, their beliefs towards problem-solving, their self-efficacy beliefs towards problem-posing, and the relationships between them were examined. Accordingly, the findings of this study, the information obtained from the analysis of the data regarding the teacher candidates' competencies and beliefs, will contribute to this field in terms of presenting a perspective on the teacher training process.

The findings of the study reveal that the competence of the teacher candidates to design MEAs was at a high level, while their beliefs towards problem-solving and their self-efficacy beliefs towards problem-posing were at a moderate level. In their study, Mousoulides and English (2008) revealed that modeling competence improves as modeling problems are studied. In addition, it was concluded that the experience of mathematical modeling influenced mathematical modeling competencies (Borromeo-Ferri & Blum, 2011; Ozer-Keskin, 2008). The fact that modeling problems were used to solve mathematical problems and teach these solutions in the mathematical modeling course taken by the teacher candidates was effective in this situation.

It is considered that the fact that such applications are included in the "Problem-Solving Approaches in Mathematics" and "Mathematical Modeling" courses of teacher candidates ensures that their problem-posing and problem-solving competencies are at high and moderate levels. Similarly Cai and Hwang (2002) examined the problem-solving and problem-posing performances of the students and determined that the activities in which problem-posing and problem-solving tasks were given contributed positively to these competencies. These results are in line with the results of Kayan (2007), Kayan and Cakiroglu (2008), Mkomange and Ajagbe (2012), and Yavuz and Erbay (2015), which examine teacher candidates' beliefs towards problem-solving.

The findings of this study revealed that in terms of academic success, the linear combinations of teacher candidates' competencies to design MEAs, their beliefs towards problem-solving, and their self-efficacy beliefs towards problem-posing did not show a significant difference. Mathematical modeling competencies are a complex structure that involves different intellectual processes in the process of transition from real life to a mathematical model and then verification of the model in a real context (Borromeo-Ferri, 2010). The reason why pre-service teachers did not differ significantly in terms of academic achievement and modeling competencies may be due to the limitations they experienced in such different intellectual processes (abstraction, synthesis, problem-solving and proofing, etc.) during their undergraduate education. Tall (2002) emphasizes actions such as abstraction, synthesis, generalization, modeling, problem-solving, and proof while describing mathematical thinking. Therefore, supporting the mathematical thinking process requires a multifaceted effort. It is clear that the theoretical knowledge in the courses alone will not support this process. Therefore, it would be beneficial to provide teacher candidates with learning experiences that support such different intellectual processes as much as possible to contribute positively to the development of their competencies.

Another finding obtained as a result of the study is that there is no significant relationship between the teacher candidates' competence in designing MEAs and their beliefs towards problem-solving and self-efficacy beliefs towards problem-posing. In the mathematical modeling process, there is a connection and interpretation phase, which is performed by using mathematical tools related to real-world problems (Blum & Borromeo-Ferri, 2016). However, this step is not included in the process when solving mathematical problems. Therefore, the fact that teacher candidates' beliefs about problem-solving and problem-posing are not related to their competence in designing MEA may be due to their previous experience in routine mathematics problem-solving. Contrary to the result of the study, the positive role of problem-posing in mathematical modeling has been stated by many researchers in the past (English, 1997; Lavy & Bershadsky, 2003; Lowrie, 2002; National Council of Teachers of Mathematics [NCTM], 2000) and does not correspond to the results of this study. On the contrary, there is a positive and moderately significant relationship between teacher candidates' beliefs toward problem-solving and self-efficacy beliefs toward problem-posing. Therefore, it can be stated that beliefs towards problem-solving affect self-efficacy beliefs towards problem-posing. In their study on problem-solving and problem-posing, Deringol (2018) and Unlu and Sarpkaya-Aktas (2016) found a moderate and high level of positive correlation between problem-solving beliefs and problem-posing self-efficacy beliefs, respectively. In this study, in parallel with previous studies, the positive relationship between problem-posing and problem-solving was confirmed (Bonotto, 2013; Kilpatrick, 1987; Peng, Cao & Yu, 2020; Silver, 1994; Silver & Cai, 1996).

In conclusion, it is thought that in order to increase the problem solving and posing beliefs of teacher candidates to a higher level, belief development studies can be carried out with them in these areas. Although mathematics teacher candidates' competencies to design MEAs were at a high level, it was determined that this situation was not related to their beliefs about problem solving and posing. However, since the mathematical modeling process is basically considered as a problem-solving process, it was expected that these beliefs of pre-service teachers would be related to MEA design proficiency. In order to examine this situation in more detail and to reveal the underlying causes, it is recommended to conduct qualitative studies with teacher candidates. The relationship between teacher candidates' academic achievements in MEAs design competencies, problem-solving beliefs, and problem-posing self-efficacy beliefs was examined and no significance was found. It is foreseen that more meaningful results can be obtained by including the variables that can reveal the situation more clearly in the study.

Öğretmen Adaylarının Model Oluşturma Etkinliği Tasarlama Yeterliği ile Problem Çözme ve Problem Kurmaya Yönelik İnançları Arasındaki İlişki

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Özet

Bu çalışmanın amacı ortaokul matematik öğretmeni adaylarının Model Oluşturma Etkinliği (MOE) tasarlama yeterlikleri, problem çözmeye yönelik inançları ve problem kurmaya yönelik öz-yeterlik inançları düzeylerinin cinsiyet ve genel akademik not ortalamasına (GANO) göre değişimi ve aralarındaki ilişkileri belirlemektir. Türkiye'de 64 ortaokul matematik öğretmeni adayının katılımıyla tasarladıkları modelleme etkinlikleri MOE yeterliklerine ilişkin "MOE tasarlama prensiplerine uygunluk kriterleri" bağlamında oluşturulmuş bir puanlama anahtarı aracılığı ile değerlendirilmiştir. Diğer yandan öğretmen adaylarının problem çözmeye yönelik inançları için 24 maddeden oluşan bir ölçek ve problem kurmaya yönelik öz-yeterlik inançları için 26 maddelik bir ölçek uygulanmış olup verilen yanıtlar nicel yöntemlerle analiz edilmiştir (tek yönlü çoklu varyans analizi, korelasyon analizi, çoklu regresyon testi). Elde edilen bulgular, öğretmen adaylarının MOE tasarlama yeterliklerinin genelde yüksek düzeyde, problem çözmeye yönelik inançları ve problem kurmaya yönelik öz-yeterlik inançlarının genelde orta düzeyde olduğunu göstermektedir. MOE tasarlama yeterlikleri, problem çözmeye yönelik inançları ve problem kurmaya yönelik öz-yeterlik inançları doğrusal kombinasyonlarının anlamlı bir farklılık göstermediği belirlenmiştir. Ancak öğretmen adaylarının problem çözmeye yönelik inançları ile problem kurmaya yönelik öz-yeterlik inançları arasında pozitif yönde ve orta düzeyde anlamlı bir ilişki olduğu belirlenmiştir. Matematiksel modellemeye yönelik deneyimin matematiksel modelleme yeterliklerini etkilediği sonucuna ulaşan birçok çalışma mevcuttur. Bu nedenle öğretmen adaylarının aldıkları matematiksel modelleme dersinde modelleme problemlerinin kullanılmış olmasının yeterlikleri arttırdığı sonucuna ulaşılmıştır. Matematik öğretmeni adaylarının MOE tasarlama yeterlilikleri yüksek düzeyde olmasına rağmen bu durumun problem çözme ve kurma inançlarıyla ilgili olmadığı belirlenmiştir. Ancak matematiksel modelleme süreci temel olarak bir problem çözme süreci olarak ele alındığından öğretmen adaylarının bu inançlarının MOE tasarım yeterliği ile ilişkili olması beklenmiştir. Bu durumu daha detaylı inceleyebilmek ve altında yatan nedenleri ortaya koyabilmek için öğretmen adayları ile nitel araştırmaların yapılması önerilmektedir.

Anahtar kelimeler: *Model oluşturma etkinliği, Problem çözme inancı, Problem kurma inancı, Matematik öğretmen adayı, Matematiksel modelleme*

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Genişletilmiş Özet

Problem: Matematiksel modellemenin birçok tanımı olmakla birlikte Ortak Temel Standartlarda (Common Core Standarts) (2010) modelleme, öğretmenlerin öğrencilerde geliştirmeye çalışması gereken matematik uygulamaları için bir standart olarak tanımlanmış olup böylece gerçek problemlerin çözümünde var olan matematiksel bilgiye erişmelerini ve kullanmalarını sağlayan bir süreç olarak kabul edilmektedir. Matematiksel modellemede temel amaç, matematiği kullanarak bir gerçek yaşam problemini anlamlandırmak ve ona uygun bir çözüm bulmaktır (Doğan, Özaltun-Çelik & Bukova-Güzel, 2021). Matematiksel modellemenin özelliklerini daha iyi ifade edebilmek için matematiksel modelleme ile matematiksel problem çözmeyi karşılaştırabiliriz. Matematiksel modelleme gerçek durumlarla başlar ve sonra bu durumlara geri döner. Matematiksel problem çözme, hem gerçek dünya durumlarını hem de teorik matematik problemlerini içerir (Kim, 2012; Pollak, 2012). Soyut olan matematiksel yapıların somut dünyaya aktarılmasının çok da kolay bir süreç olmadığı göz önünde bulundurulduğunda matematiksel modelleme, ileri düzey bilişsel beceriler gerektiren görevler içerirken, matematiksel problem çözme, farklı bilişsel beceriler gerektiren görevler içerir.

Matematiksel modelleme ve problem çözmenin bilişsel becerileri içerme yoğunlukları açısından farklılaştığı noktalar bulunsa da Lesh ve Doerr (2003) de matematiksel modellemeyi problem çözme aktiviteleri olarak görmüş ve bu aktivitelerin bireylerin problem çözme sürecindeki matematiksel kavramları, ilişkileri ve davranışları anlamalarını sağladığını savunmuştur. Problem çözme sürecinde ortaya çıkan problem kurmanın problem çözme ile yakından ilişkili olması ve iki becerinin birbirini geliştiren yönlerinin olması problem kurma ve problem çözmenin sıklıkla birlikte anılmasına yol açmıştır. Problem kurmada bağlam bilgisine yapılan vurgu benzer şekilde matematiksel modellemede de bulunmaktadır. Öğrencilerin bu süreçte verilen bağlama bağlı olarak verileri gerçek yaşamda yorumlaması, çözüm için bu gerçek yaşam bağlamını kullanması ve sonrasında ulaşılan çözümün gerçek yaşamda tekrar gözden geçirilerek genellemeye varması beklenmektedir. Bu açıdan gelişmiş bir problem çözme süreci olan matematiksel modellemede problem çözme ve problem kurmanın ilişkili bir şekilde süreçte yer alacağı düşünülebilir.

Matematiksel modellemedeki öğrenme sürecinde sıkça kullanılan model oluşturma etkinlikleri (MOE) belirli prensiplere ve bileşenlere sahip olacak şekilde tanımlanmış ve rutin olmayan modelleme etkinlikleridir. Her model oluşturma etkinliği öğrencilerin gerçek yaşamda karmaşık bir durumu matematiksel olarak yorumlamalarını ve kendilerine danışan bir kişiye yardımcı olmak için matematiksel bir tanım, işlem ve metot oluşturmalarını gerektirir (Mousoulides & English, 2008; Lesh & Zawojewski, 2007). Matematiksel modelleme ve matematikte problem çözme ile ilgili eğitim alan öğretmen adaylarının MOE tasarlama sürecinde boyunca da hem problem çözme, hem de problem kurmaya yönelik bilgi ve becerilere sahip oldukları kabul edilmiştir. Bu bağlamda bu araştırmada; ortaokul matematik öğretmeni adaylarının MOE tasarlama yeterlikleri, problem çözmeye yönelik inançları ve problem kurmaya yönelik öz-yeterlik inançları düzeylerinin cinsiyet ve genel akademik not ortalamasına (GANO) göre değişimi ve aralarındaki ilişkilerin belirlenmesi amaçlanmıştır. Bu amaç doğrultusunda;

1. Ortaokul matematik öğretmeni adaylarının MOE tasarlama yeterlikleri, problem çözmeye yönelik inançları ve problem kurmaya yönelik öz-yeterlik inançları düzeyleri nedir?

2. Ortaokul matematik öğretmeni adaylarının MOE tasarlama yeterlikleri, problem çözmeye yönelik inançları ve problem kurmaya yönelik öz-yeterlik inançları akademik başarılarına göre farklılık göstermekte midir?

3. Ortaokul matematik öğretmeni adaylarının problem çözmeye yönelik inançları ve problem kurmaya yönelik öz-yeterlik inançları MOE tasarlama yeterliklerinin birer anlamlı yordayıcısı mıdır?

sorularına cevap aranmıştır.

Yöntem: Ortaokul matematik öğretmen adaylarının MOE tasarlama yeterlikleri, problem çözmeye yönelik inançlar ve problem kurmaya yönelik öz-yeterlik inançları ve aralarındaki ilişkiyi ortaya çıkarmayı amaçlayan bu araştırmada karma yöntem kullanılmıştır. Araştırma problemi ve sorularının önemi, karma yöntem araştırma deseni için kilit bir ilkedir. Bu çalışmada öncelikle öğretmen adaylarının MOE tasarlama yeterlikleri problem olarak belirlenmiştir. Bu nedenle öncelikle nitel verilerin toplanması ile araştırma süreci başlamıştır. Daha sonra öğretmen adaylarının MOE tasarlarken problem kurma ve çözme süreçlerinden geçtikleri göz önünde bulundurularak bu becerilere dair inançlarının ne düzeyde olduğu ve bu bileşenler arasında bir ilişki olup olmadığı merak edilmiştir. Böylece nicel veri toplama süreci bu inançları belirlemeye yönelik sürdürülmüştür. Bu bağlamda çalışmada iç içe karma desen kullanılmıştır. Çalışmanın örneklemini; ilköğretim matematik öğretmenliği programında öğrenim gören 64 öğretmen adayı oluşturmaktadır. Bu çalışmanın amacına uygun olacak şekilde öğretmen adaylarının "Matematikte Problem Çözme Yaklaşımları" ve "Matematiksel Modelleme" derslerini almış olmaları bir ölçüt olarak belirlenmiş bu bağlamda dördüncü sınıfta öğrenim gören öğretmen adayları çalışmanın örneklemini oluşturmuştur. Araştırmada öncelikle katılımcıların her birinden birer MOE tasarlamaları istenmiştir. Öğretmen adayları tasarladıkları etkinlikleri pilot uygulama kapsamında ortaokul öğrencilerine uygulamış ve alınan dönütler doğrultusunda etkinliklerine son halini vermişlerdir. Tasarlanan MOE'lerin uygunluğunu değerlendirmek için Doruk (2019) tarafından geliştirilen "MOE tasarlama prensiplerine uygunluk kriterleri formu" kullanılmıştır. Böylece öğretmen adaylarının MOE tasarlama yeterlikleri belirlenmiştir. Problem çözmeye yönelik yeterlik inançlarını belirlemek için Kloosterman ve Stage (1992) tarafından geliştirilmiş ve Hacıömeroğlu (2011) tarafından Türkçeye uyarlanmış olan 5'li Likert tipindeki "Matematiksel Problem Çözmeye İlişkin İnanç Ölçeği" ve problem kurmaya yönelik öz-yeterlik inançlarını belirlemek için Kılıç ve İncikabı (2013) tarafından geliştirilen 5'li Likert tipindeki "Problem Kurma Özyeterlik İnanç Ölçeği" kullanılmıştır. Katılımcıların MOE tasarlama yeterliklerini belirlemek öğretmen adaylarının tasarladıkları MOE'ler, Doruk (2019) tarafından geliştirilen "MOE tasarlama prensiplerine uygunluk kriterleri formu" kullanılarak değerlendirilmiştir. Öğretmen adaylarının MOE tasarlama yeterlikleri, problem çözmeye yönelik inançlar ve problem kurmaya yönelik öz-yeterlik inançlarında akademik başarılarına göre anlamlı farklılık olup olmadığını tespit için tek yönlü çoklu varyans analiz testi kullanılmıştır. Problem çözmeye yönelik inançları ve problem kurmaya yönelik öz-yeterlik inançları MOE tasarlama yeterliklerinin birer anlamlı yordayıcısı olup olmadığını analiz etmek için çoklu regresyon testi kullanılmıştır.

Bulgular: Öğretmen adaylarının çoğunluğunun MOE tasarlama yeterlikleri yüksek düzeyde iken, problem çözmeye yönelik inançları ve problem kurmaya yönelik öz-yeterlik inançları orta düzeydedir. Diğer yandan öğretmen adaylarının akademik başarılarına göre MOE tasarlama yeterlikleri, problem çözmeye yönelik inançları ve problem kurmaya yönelik öz-yeterlik inançları puan ortalamalarının kendi içinde yakın olduğu görülmektedir. Çok değişkenli örneklemlerin varyanslarını karşılaştırmak için kullanılan parametrik bir test olan Box'ın M istatistiğine göre yayılma matrisinin homojenlik varsayımı sağlanmadığı görülmüştür ($F=1{,}710$, $p=0{,}18$). Bundan dolayı Wilk's Lambda değeri yerine Pillai Trace testi sonuçları yorumlanmıştır. Pillai Trace testi sonucu akademik başarı açısından öğretmen adaylarının MOE tasarlama yeterlikleri, problem çözmeye yönelik inançları ve problem kurmaya yönelik öz-yeterlik inançları doğrusal kombinasyonlarının anlamlı bir farklılık göstermediğini ortaya koymuştur (Pillai Trace $\lambda= 0{,}163$, $F= 0{,}848$, $p=0{,}601$). Öğretmen adaylarının MOE tasarlama yeterlikleri ile akademik başarı değişkenine ait sonuçlar incelendiğinde anlamlı bir farklılık olmadığı görülmektedir ($F=1{,}851$, $p>0{,}01$). Öğretmen adaylarının problem çözmeye yönelik inançlarının akademik başarılarına göre anlamlı farklılık göstermediği de görülmektedir ($F=0{,}615$, $p>0{,}01$) ve benzer olarak öğretmen adaylarının problem kurmaya yönelik öz-yeterlik inançlarının akademik başarılarına göre anlamlı farklılık göstermediği de belirlenmiştir ($F=0{,}519$, $p>0{,}01$). Problem çözmeye yönelik inançları, problem kurmaya yönelik öz-yeterlik inançları ile MOE tasarlama yeterlikleri arasında anlamlı bir ilişkinin olup olmadığını belirlemek amacıyla yapılan Pearson korelasyon analizi sonucunda problem çözmeye yönelik inançları ile problem kurmaya yönelik öz-yeterlik inançları arasında pozitif yönde ve orta düzeyde anlamlı bir ilişki ($r=.442$, $p<.01$) bulunmuştur. Diğer yandan MOE tasarlama yeterlikleri ile problem çözmeye yönelik inançları ve problem kurmaya yönelik öz-yeterlik inançları arasında anlamlı bir ilişki ($r=.195$, $r=.105$, $p>.01$) olmadığı elde edilmiştir. Problem çözmeye yönelik inançları ($\beta = .185, p > .05$) ve problem kurmaya yönelik öz-yeterlik inançlarının ($\beta = .024, p > .05$) MOE yeterliklerinin anlamlı yordayıcısı olmadığı görülmektedir.

Öneriler: Öğretmen adaylarının problem çözme ve kurma inançlarını daha üst düzeye çıkarmak için onlarla bu alanlarda inanç geliştirme çalışmalarının yapılabileceği düşünülmektedir. Matematik öğretmeni adaylarının MOE tasarlama yeterlilikleri yüksek düzeyde olmasına rağmen bu durumun problem çözme ve kurma inançlarıyla ilgili olmadığı belirlenmiştir. Ancak matematiksel modelleme süreci temel olarak bir problem çözme süreci olarak ele alındığından öğretmen adaylarının bu inançlarının MOE tasarım yeterliği ile ilişkili olması beklenmiştir. Bu durumu daha detaylı inceleyebilmek ve altında yatan nedenleri ortaya koyabilmek için öğretmen adayları ile nitel araştırmaların yapılması önerilmektedir. Öğretmen adaylarının MOE tasarım yeterlikleri, problem çözme inançları ve problem kurma öz-yeterlik inançlarındaki akademik başarıları arasındaki ilişki incelenmiş ve anlamlı bulunmamıştır. Çalışmada durumu daha net ortaya koyabilecek değişkenlere yer verilerek daha anlamlı sonuçlara ulaşılabileceği öngörülmektedir.

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Appendix 1. *Reflections from the pilot application*

Appendix 2. *A sample MEA created by teacher candidates*

Will you be my hope?

Every year, thousands of people in the world are faced with burns that require treatment. Infection and fluid loss in the exposed area as a result of burning can have fatal consequences for the patient. Even if the patient is saved as a result of the treatment, the adhesions that occur because the skin cannot form in the area hinders the patient's movements, impairing the quality of life and aesthetic appearance. In such cases, doctors commonly called "Skin graft"; performs a medical treatment in which healthy skin is removed from the donor and attached to the injured area. However, the burns can sometimes be so large that when the skin that can be taken from the donor is insufficient, the treatment fails and the person can even die. Even if the necessary skin is provided with this method, the healing process of the patient is quite painful and burn scars remain.

Another type of treatment for the treatment of the damaged area as a result of burning is "Artificial Skin". The skin, which is necessary for the treatment of burns, was produced by organizing and shaping the person's own blood and stem cells in the laboratory environment. Artificial skins prevent bacterial infection and fluid loss by closing wounds. Since the skin is produced entirely with the person's own tissue, there is no problem in its harmony with the body. It also ensures that there are almost no scars on the patient's skin. Thus, it helps the person to overcome the treatment process with the least damage, both biologically and psychologically. However, due to the fact that the project is still a new application, the high cost of closing the budget deficit may force some patients financially. The treatment cost is calculated based on the surface area of the artificial skin to be used for the patient. For this reason, care is taken not to produce more skin than necessary in order not to force the patients financially.

Deniz, who had serious burns on her face and body as a result of an accident, was taken to the hospital by the medical teams as injured.

As a member of the medical team at the hospital, you have been asked to develop a method for calculating the amount of artificial skin to be produced in the laboratory for Deniz's treatment. Develop a method that calculates the amount of artificial skin you will produce in the laboratory for the treatment of the patient. Make sure that this method is a method that will allow you to practically calculate the amount of artificial skin required in the treatment of subsequent patients with burns.