Research Article

PROBLEM SOLVING INSTRUCTION: PROSPECTIVE MATHEMATICS TEACHERS' OPINIONS AND PROBLEM SOLVING PROCESSES

Emel TOPBAŞ-TAT
Dr. Instructor, Necmettin Erbakan University, etopbastat@konya.edu.tr
ORCID Number: 0000-0002-1487-3027

Received: 26.11.2017 *Accepted: 29.05.2108*

ABSTRACT

The main purpose of this research is to examine the problem solving processes of prospective elementary mathematics teachers and to identify how the problem solving instruction affects prospective teachers' problem solving processes. It is also aimed to investigate the prospective teachers' opinions about problem solving process and problem solving instruction. This qualitative study was conducted with the participation of 36 prospective elementary mathematics teachers enrolled in an elective course entitled as *Problem solving* in 2016-2017 academic year. At the beginning and at the end of the semester, prospective mathematics teachers were asked to pose and solve a problem. At the end of the *problem solving* course, interviews were conducted with seven prospective mathematics teachers. Descriptive analysis method was used for data analysis. The results of the research showed that before the problem solving course, prospective mathematics teachers did not follow problem solving steps and solved the problems they wrote by using equations. After the problem solving course, they have begun to apply the problem solving steps and strategies explained to them during the lessons. It was also determined that prospective teachers had positive opinions about problem solving instruction. Similarly, prospective mathematics teachers stated that *problem solving* course has enabled a lot of experience and valuable knowledge which would be useful to them in profession of teaching and increased their success and self-confidence.

Keywords: Problem solving process, problem solving strategies, problem solving instruction, prospective teacher.

INTRODUCTION

The main purpose of the education is to teach people to think, to use their mental powers and to become better problem solvers (Gagne, 1980). In this respect, skills such as guessing and problem solving gain importance while the importance of calculating with paper and pencil is gradually decreasing in mathematics education (TTKB, 2009). The problem is defined as "a situation that confronts a person, that requires resolution, and for which the path to the solution is not immediately known" (Posamentier and Krulik, 1998: 1). In the middle school mathematics curriculum, the problem is defined as "questions whose solution path is previously unknown and solution is not immediately obvious" (TTKB, 2013). Problem solving is the process of applying existing knowledge to new situations (Reys, Suydam, Lindquist and Smith, 1998; TTKB, 2013). Problem solving is the most important learning outcome for life (Jonassen, 2000; Phye, 2001). The individual needs to have appropriate problem solving skills to be able to overcome the problems that confront. Mathematical problem solving is considered to be related to solving problems in everyday life (NCTM, 2000). From this point of view, problem solving skill not only helps solve the problems in mathematics or other disciplines but also help to make everyday life easier. While the middle school mathematics curriculum in Turkey emphasizes the development of problem solving skills, it is also stated that developing these skills is one of the main objectives of mathematics education (TTKB, 2013). Similarly, many mathematics educators argue that improving problem solving skills is one of the main objectives of mathematics education (e.g., Posamentier and Krulik, 1998; Schoenfeld, 1992).

Problem solving is a process. However, many teachers and students consider that it is important to reach just the result by ignoring this process. For example, students have a tendency to obtain answer by applying appropriate numerical operations to the problems they encounter (Altun and Arslan, 2006). Similarly, Kayaaslan (2006) found that students believed that there was only one correct solution way to solve a problem. Kayan and Çakıroğlu (2008) determined that the prospective teachers believed that they should follow predetermined routine steps in problem solving. Problem solving is a process that requires much more than the application of a predetermined routine algorithm (Lester, 1994). Polya (1973) proposed a four-step framework for solving mathematical problems. These steps are: (1) understanding the problem, (2) devising a plan, (3) carrying out the plan, and (4) looking back. Middle school mathematics curriculum also suggests a process including (1) understanding the problem, (2) planning the solution, (3) carrying out the plan, (4) controlling the accuracy and validity of the solution and (5) generalizing the solution and posing similar/original problem (TTKB, 2013). It also encompasses critical behaviors for this process. For example, some of the critical behaviors involved in the process of problem solving are: determining what is given and what is asked for the understanding phase; assessing the appropriateness of a strategy for the planning phase; executing the operations and algorithms required by the strategy for carrying out the plan; evaluating different solutions of the problem in controlling phase; and being able to create realistic problems that fit the information available for the stage of generalization and similar / original problem posing. Some research studies showed that problem solving instruction about problem solving process and behaviors was effective in increasing problem

solving success (e.g., Altun, 1995; Arslan and Altun, 2007; Charles and Lester, 1984; Lee, 1982; Yıldız, 2008). Problem solving instruction for the development of problem solving behaviors helps to improve problem solving success, improve understanding of mathematical concepts, and develop self-confidence in mathematics and positive attitudes towards mathematics (Baykul, 2014). In this context, in this study, to improve the problem solving skills of the prospective teachers, problem solving instruction which includes the problem solving steps was applied within the scope of *problem solving* course.

An important component of problem solving process is problem posing (English, 2003; Turhan and Güven, 2014). Therefore, problem posing has an active role in the problem solving process. Posing a problem involves creating a new problem or reshaping the given problem (Silver, 1994). In the mathematics classrooms, problem posing can be used as a purpose or a tool for teaching (Kilpatrick, 1987). According to Kilpatrick, problem posing is an important part of mathematical thinking. Lin (2004) suggests that problem posing is a useful tool in assessing student understanding. According to Crespo (2003), one of the features of effective mathematics teaching is to pose mathematical tasks and problems. According to Gonzales (1998), problem posing is the fifth and final step of problem solving. In addition, the middle school mathematics curriculum suggests a process involving the problem posing in improving problem solving skills (TTKB, 2013). For these reasons, in the present study, the problem posing was considered as the last phase of the problem solving process by adding to Polya's (1973) problem solving steps.

If our goal is to improve students' problem solving skills, we can only achieve this goal through teachers (Thompson, 1989). The role of the teacher in the problem solving process should not be ignored and activities to improve their skills and competencies should be organized. Teachers' knowledge and skills are important factors affecting student achievement (Ball, Thames and Phelps, 2008; Franke and Kazemi, 2001). Dooren, Veschaffel and Onghena (2003: 30) stated the importance of developing pre-service teachers' problem solving skills as

> "Considering the indications in the literature of the impact of teachers' subject-matter knowledge and pedagogical content knowledge on pupils' learning processes, we should encourage future primary and secondary school teachers to master and appreciate algebraic as well as arithmetical problem solving skills."

For these reasons, focus of this study is on prospective teachers' problem solving processes.

Learning mathematics involves thinking about mathematics and conceptualizing problem solving strategies as well as acquiring basic concepts and skills, and realizing mathematics as an important tool in real life (TTKB, 2013). In fact, sometimes people do not realize that they use specific strategies while solving problems in everyday life. For example, when searching for an address we often try to find a pattern amongst the house numbers along a street (Posamentier and Krulik, 1998). Problem solving strategies can be defined as ways to apply for solving the problem (Baykul, 2014). Posamentier and Krulik (1998) present a list of problem solving strategies. The strategies are *working backwards*, *finding a pattern*, *making a drawing (visual representation)*,

organizing data, *solving a simpler analogous problem*, *intelligent guessing and testing*, *logical reasoning*, *considering extreme cases*, *adopting different point of view*, and *accounting for all possibilities*. Similarly, Baykul (2014) lists problem solving strategies namely, *writing mathematical sentence*, *guessing and testing*, *drawing shapes or diagrams*, *role-playing*, *using models*, *making a table*, *using structures*, *organizing a list*, *working backwards*, *logical reasoning*, *simplifying,* and *criticizing given knowledge*. Some research studies reached the conclusion that teaching problem solving strategies enhanced problem solving skills (e.g., Arslan and Altun, 2007; Charles and Lester, 1984; Çalışkan, 2007; Lee, 1982; Schoenfeld, 1979). However, the teaching of problem solving strategies is an important requirement that can improve not only our point of view on mathematical problems, but also our point of view on everyday life problems (Posamentier and Krulik, 1998). In mathematics lessons, it is important to give students opportunities to build problem solving and reasoning skills as well as to build procedural and conceptual knowledge. In this regard PISA (The programme for International Student Assessment) and TIMSS (Trends in International Mathematics and Science Study) are important projects to aim at measuring students' mathematical problem solving skills and interpreting and application skills of mathematical knowledge (Toptaş and Gözel, 2017). The results of international examinations such as PISA and TIMSS (MEB, 2016a, 2016b) and some research studies (e.g., Soylu and Soylu, 2006) show that students' problem solving success are not at the desired level. According to Charles and Lester (1982), problem solving success of students is affected by cognitive, affective and experience factors. These factors are:

1) Cognitive factors, such as analytical thinking skills, reasoning skills, computational skills, memory
2) Affective factors, such as interest in problem solving or problem situations, motivation, willingness to solve problems, self-confidence, stress, anxiety, uncertainty, patience
3) Experience factors, such as age, content knowledge, knowing problem solving strategies.

Aydogdu and Ayaz (2008) determined that the majority of students who stated that they experienced difficulty in solving the problem believed that their difficulties resulted from challenges in understanding or in thinking in detail to solve the problem. In addition, they stated that most of the students who had difficulties in problem solving experienced difficulties due to lack of prior learning. The general characteristics of the students who gained problem solving skills and who had positive attitudes towards problem solving were determined as having patience, high self-confidence and comprehensive understanding of the problem, and being able to use the problem solving steps very well. In addition, students need opportunities to practice with problem solving strategies (Herr and Johnson, 1994). "In fact, it is often the teachers themselves who are not aware of the many problem-solving strategies that can be used to provide efficient and elegant solutions to many problems" (Posamentier and Krulik, 1998: xv). It is therefore necessary to develop problem solving instruction enhancing awareness of these strategies for prospective teachers. For this purpose, in this study, problem solving instruction which includes problem solving strategies was applied to improve problem solving skills of prospective teachers.

In the literature, there are many studies on mathematical problem solving. For example; there are many studies on problem posing skills of students, teachers or prospective teachers (e.g., Işık and Kar, 2012; Kılıç,

2013, 2014; Korkmaz and Gür, 2006; Tertemiz and Sulak, 2013; Toluk-Uçar, 2009; Turhan and Güven, 2014). Similarly, some studies examined the effects of different problem solving approaches on various variables such as attitude, achievement or problem solving performance (e.g., Arslan, 2002; Ay and Bulut, 2014; Cankoy and Darbaz, 2010; Harskamp and Suhre, 2007; Higgins, 1997; Posluoğlu, 2002). There are different studies on prospective teachers' problem solving process in the literature. For example, Demircioğlu, Argün and Bulut (2010) investigated the relationship between metacognitive behaviors in problem solving process and academic achievement of prospective secondary mathematics teachers. Dede (2004) investigated the strategies that the prospective teachers used while writing algebraic word problems in the form of equation. Dede and Yaman (2005) in their studies aimed to determine prospective mathematics teachers' problem solving and problem posing skills found that prospective teachers were able to solve problems but did not pose new problems from given situations. It can be said that most of the studies in the literature on the effects of different problem solving approaches was conducted with elementary school or middle school students (e.g., Higgins, 1997; Yazgan, 2007). However, there are few studies with prospective teachers (e.g., Ay and Bulut, 2014; Cankoy and Darbaz, 2010).

The main purpose of this study is to identify the problem solving processes of prospective elementary mathematics teachers and to determine how the problem solving instruction affects their problem solving processes. The other aim is to determine the opinions of prospective teachers about the problem solving process and *problem solving* course. Accordingly, the research problems are:

1. Which processes are involved in prospective elementary mathematics teachers' problem solving before the problem solving course?

1.1. What are the steps that prospective mathematics teachers follow to solve problems before the problem solving course?

1.2. What are the problem solving strategies that prospective mathematics teachers use to solve problems before the problem solving course?

2. Which processes are involved in prospective elementary mathematics teachers' problem solving after the problem solving course?

2.1. What are the steps that prospective mathematics teachers follow to solve problems after the problem solving course?

2.2. What are the problem solving strategies that prospective mathematics teachers use to solve problems after the problem solving course?

3. What are the opinions of prospective elementary mathematics teachers regarding *problem solving* course?

As Burkhardt (1988, as cited in Schoenfeld, 1992) notes, teaching problem solving is harder for the teacher in these ways: mathematically, pedagogically, personally. It is therefore important to examine problem solving processes and approaches of prospective teachers and to develop courses for improving their problem solving processes. In this research, prospective teachers' approaches to the problem solving process and their views on

problem solving instruction were examined and suggestions were made in the direction of the results. It is thought that the results of this study will contribute to the problem solving literature by revealing the problem solving processes of the prospective mathematics teachers and contributions of problem solving instruction to their problem solving processes.

METHOD

In this section, information about research design will be given first. Then, participants in the study and procedure will be introduced. Finally, it will be mentioned about the data collection tool and data analysis procedure.

Research Design

This is a qualitative study aiming to reveal the steps and strategies that prospective elementary mathematics teachers use to solve problems and to determine the contribution of problem solving instruction to their problem solving processes by interviewing and analyzing written data. In order to investigate the problem solving processes of the prospective teachers and the contributions of the problem solving instruction, at the beginning and at the end of the semester, the prospective teachers were asked to pose and solve a problem. After the problem solving course, interviews were conducted with seven volunteer prospective teachers, since it is a highly effective method of obtaining information about the experiences and perceptions of individuals (Briggs, 1986). In the study, "interview form approach" (Patton, 1987) was used to obtain in-depth information.

Participants

In the fall semester of 2016-2017 academic year, 36 prospective elementary mathematics teachers (31 females and 5 males) enrolled in the elective course entitled as *problem solving* participated in this study. This research was carried out within the scope of *problem solving* elective course in Elementary Mathematics Teacher Education Department of Education Faculty of a state university in Central Anatolia Region. The prospective teachers participating in the research were between the ages of 20-22, 86% of whom were female and 14% of whom were male. 58% of the participants had the weighted grade point averages (GPA) between 2.50 and 3.00 and 39% of them had GPA between 3.01-3.60. Participants included one prospective teacher with a GPA below 2.50. Participants stated that they have never received any training in problem solving processes and strategies. After the *problem solving* course, individual interviews was conducted with seven volunteers, 4 females and 3 males.

Procedure

This research was carried out within the scope of an elective course entitled *problem solving* in Elementary Mathematics Teacher Education Department of Education Faculty of a state university in Central Anatolia Region. In order to investigate the problem solving processes of the prospective teachers and the effect of the

problem solving instruction on problem solving process, in the first week of the *problem solving* course lasting 14 weeks (total 28 hours) and after this course, the prospective teachers were asked to pose and solve a problem. During the *problem solving* course, prospective mathematics teachers were informed about problem definition, problem solving steps, problem solving strategies, application of problem solving strategies in daily life and assessment techniques for students' progress in problem solving (e.g. self-assessment, holistic techniques etc.). During the first week of the course, prospective teachers were informed about problem definition, differences between problem and exercise, and problem solving steps. During the lessons, participants have learned the problem solving strategies, their application in daily life, the way to be followed in the use of the strategy, and their application in problems. After this teaching, various problems were presented and discussions were made about problem solving steps and the use of the strategy in the solution process. During the problem solving lessons, the problem solving steps were discussed with the whole class after the individual study and all the different solution strategies offered by the prospective teachers for each problem were shared with the whole class. After the strategy teaching was completed, prospective teachers encountered with different problems that could be solved with more than one strategy to provide opportunities to apply what they have learned.

The *problem solving* course covered working backwards, finding a pattern, making a drawing (visual representation), making a systematic list, solving a simpler analogous problem, intelligent guessing and testing, and logical reasoning strategies (Baykul, 2014; Posamentier and Krulik, 1998). In the problem solving process, Polya's (1973) problem solving steps was applied by adding the "problem posing" step. Posing a problem can involve both generation of new problems and reformulation of given problems (Silver, 1994). In the present study, during the problem posing step, the prospective teachers was asked to write a problem without changing the context of the given problem completely. A similar process is suggested in middle school mathematics curriculum as (1) understanding the problem, (2) planning the solution, (3) carrying out the plan, (4) controlling the accuracy and validity of the solution and (5) generalizing the solution and posing similar/original problem (TTKB, 2013).

Data Collection Tool

In order to investigate the problem solving processes of the prospective teachers and the effect of the problem solving instruction, in the first week of the *problem solving* course and after the course was completed, they were asked to pose and solve a problem.

After the course was completed, individual interviews were conducted with seven volunteer prospective teachers. During the interviews, an interview form consisting of eight open-ended questions was used to reveal the opinions of prospective teachers about the problem solving process and instruction. The interview form was developed in line with the research questions and the information found in the literature. The questions on the interview form was prepared to determine prospective teachers' opinions on problem solving steps, problem solving strategies and problem solving instruction. Firstly, questions related to problem solving steps,

problem solving strategies and problem solving instruction were written. Then, recommendations of two experts were taken into consideration and the final interview questions were formed. Then, the pilot study was conducted with two prospective teachers and the final interview form was developed. The interviews were conducted by the researcher and audiotaped with the permissions of the participants.

Data Analysis

In the current study, the data were analyzed with the help of thematic analysis. In such analysis, the data can be presented through the themes set out by the research questions or through the questions / dimensions used in the interview and observation processes (Yıldırım and Şimşek, 2006).

Written data including problems and their solutions obtained at the beginning and end of the *problem solving* course were used to determine the prospective mathematics teachers' problem solving processes. While the problem solving process was determined, it was investigated whether prospective teachers solved the problem directly or followed the problem solving steps namely, understanding the problem, devising a plan, carrying out the plan, checking/looking back and posing a new problem. During the step of understanding the problem, the student can state the problem in his/her own words, write the problem in summary, determine what is given and what is asked, draw the appropriate drawings. In devising a plan step, it should be decided which strategy will be used to solve the problem and how the strategy will be implemented in the solution. It may be necessary more than one strategy to solve some problems. It would be appropriate to specify these strategies at devising a plan step. Checking can be done in different ways at checking/looking back step. For example, sometimes the problem can be resolved with a different strategy; sometimes the person can try to reach what is given by working backwards from the result; or the logical consistency of the problem can be controlled (Baykul, 2014). Similarly, it can be checked each step during the problem solving process. This information was used as a criterion for assessing the solutions of the prospective teachers in terms of problem solving process. In addition, the data were also reported as percentages and frequencies. The data obtained from the interviews at the end of the problem solving instruction were used to determine the opinions of prospective teachers about the problem solving process and instruction.

In data analysis, written solutions of prospective teachers were analyzed under the themes, problem solving steps and problem solving strategies. Interviews were examined under the themes namely, opinions about problem solving steps, problem solving strategies, and problem solving instruction. Direct quotes were included in presentation of findings and abbreviations were used such as PT1, PT2 to indicate prospective teachers. To ensure reliability in data analysis, the same data set was examined separately by two experts. The issues of consensus and divergence within the scope of the themes and sub-themes were discussed; it was decided that the data should be presented under the themes of "problem solving process" and "opinions about problem solving instruction". The agreement rate was calculated as 0.93 using the reliability formula proposed by Miles and Huberman (1994). The result shows that there is a high rate of agreement between two experts and that the analysis is reliable.

RESULTS

As a result of the analysis of the data, the findings were examined under the themes namely problem solving process and opinions about problem solving instruction. The theme of problem solving process was composed of sub-themes: problem solving steps and problem solving strategies. Percentages and frequencies of developmental findings are summarized in Table 1.

Table 1. Developmental Findings Before and After Problem Solving Instruction

	Before the instruction		**After the instruction**	
Problem Solving Steps	f	%	f	%
Direct Solution	34	94,4	0	0
Understanding the problem	2	5,6	36	100
Making a plan	0	0	36	100
Carrying out the plan	0	0	36	100
Looking back	0	0	34	94,4
Posing a new problem	0	0	30	83,3
Following all steps	0	0	30	83,3
Problem Solving Strategies				
Making a systematic list	0	0	11	30,6
Working backwards	0	0	7	19,4
Finding a pattern	0	0	5	13,9
Making a drawing	0	0	5	13,9
Logical reasoning	0	0	3	8,3
Intelligent guessing and testing	0	0	3	8,3
Solving a simpler analogous problem	0	0	1	2,8
Forming and solving equations	32	88,9	0	0
Calculations with four operations	4	11,1	1	2,8

Problem Solving Process

In this part, findings about problem solving steps and problem solving strategies will be presented under the main theme of problem solving process.

Problem Solving Steps

According to the results of the study, before the *problem solving* course, prospective mathematics teachers did not follow problem solving steps and solved the problems they wrote directly without following a clear problem solving process. Only two prospective teachers (5.56%) were made explanations for the understanding of the problem. At the end of the problem solving instruction, while solving the problem, 30 prospective teachers (83.33%) made explanations about problem solving steps: understanding of the problem, devising a plan, carrying out the plan, looking back/checking and writing a new problem. Four prospective teachers (11,11%) did not follow only a new problem posing step but two prospective teachers (5,56%) did not follow both looking back and posing a new problem steps. Findings indicated that prospective mathematics teachers did not follow problem solving steps before the *problem solving* course. However, at the end of the problem solving course, it was determined that the majority of the prospective teachers followed the problem solving

steps namely understanding the problem, devising a plan, carrying out the plan, looking back and writing a new problem. Moreover, interviews revealed that prospective teachers thought that it was useful and necessary to follow these steps in problem solving process.

In the interviews, the prospective teachers stated that when they encountered a problem, they firstly tried to understand the problem, thought about whether they had encountered a similar problem before, and thought about the solution way. Five prospective teachers stated that in the problem solving process after reading the problem they firstly tried to understand. One prospective teacher stated that she firstly thought whether she had encountered such a problem before; and one prospective teacher said that she firstly thought how she could solve it.

All of the prospective teachers participating in the interviews stated that it was important to follow the problem solving steps during the problem solving process. Below some examples are given of the opinions of prospective teachers on understanding the problem step.

> Firstly, understanding the problem is very important in the problem solving process. A good start is half the work. Similarly, understanding of the problem is as important as solving it. (PT2)

> Firstly, I think understanding is important. If we do not understand the problem, the other steps lose their importance. If you do not understand the problem, the plan you implement will probably be wrong. So, understanding the problem is the most important thing while solving a problem. (PT5)

Prospective teachers stated that understanding the concepts in the problem was also important, and that the conceptual confusion could negatively affect the problem solving process. Some examples of the opinions of prospective teachers on the concepts in the problem are as follows:

> Concepts are important in terms of understanding and understanding is important in terms of solving the problem because the difficulties with the concepts prevent the understanding and also the other steps. (PT1)

> Concepts in the problem and understanding these concepts are important in problem solving process. We can't perceive the problem as a problem if we are not familiar with concepts in the problem. So I think students should be familiar with the concepts in the problem (PT7).

In addition, the prospective teachers stated that in addition to understanding steps, the other problem solving steps namely devising a plan, carrying out the plan, looking back and posing a new problem were also important, and that these steps should be followed during the problem solving process. Below some examples are given of prospective teachers' opinions on problem solving steps.

> Understanding is very important. If there is a problem in understanding, even if the correct answer is obtained, it does not mean that it solved correctly. The second step is also very important. In fact, every step we have learned about the problem solving process is important. (PT7)

> I realized that I had not checked the solution until now. It could be controlled by strategies. (ÖA5)

Prospective teachers stated that they had difficulties in the first week of problem solving course in a new problem posing step which is the last stage of problem solving but they were satisfied with having experienced this process. Below some examples are given of the opinions of prospective teachers on the problem posing step.

> Posing a new problem was initially challenging. Over time, we started to make sense. We could not do it at first. It's good that we have learned to write a new problem. (PT6)

> Posing a new problem help me look at the problem from a different perspective. I have learned to look at the problems in the eyes of others to pose a new problem. (PT1)

The interviews with the prospective teachers revealed that the problem posing activities affected the thinking of the prospective teachers, contributed to their professional knowledge of teaching and helped to develop different perspectives for the problems and to look at the problems in the eyes of others.

Problem Solving Strategies

The results of the study showed that before the problem solving instruction, 32 prospective teachers (88.89%) solved the problems they wrote by solving the equations or wrote the questions directly asking the solution of the equations. Only four prospective teachers (11.11%) solved the problems they wrote using calculations based on four operations without forming equations.

According to the results of the study, after the problem solving instruction the majority of the prospective teachers solved the problems they wrote by using at least two different strategies. Strategies used by prospective teachers in solving the problems were making a systematic list (30.6%), working backwards (19.4%), finding a pattern (13.9%), making a drawing (13.9%), logical reasoning (8.3%), intelligent guessing and testing (8.3%) and solving simpler analogous problem (2.8%). One prospective teacher solved her problem by using calculations based on four operations. Prospective teachers solved the problem again with different strategy at the looking back step. It was also determined that nine prospective teachers used the equations while checking the solution.

According to the results of the interviews, prospective teachers identified the problem solving strategy as the way to solve the problem. Below some examples are given of prospective teachers' opinions on problem solving strategies.

> Problem solving strategy is the path we follow in problem solving. If there is a way we can follow, we can move forward with more clear steps. For this reason, the problem solving strategy is also a guide… I use mostly intelligent guessing and testing and logical reasoning strategies. I think making a systematic list is like a waste of time. I used to solve the problems mostly with equations before the problem solving course… Although some of the problems can be solved with some strategies very easily, I do not prefer using them. Thinking the path you know best as the shortest path, I prefer to use the strategy that I feel closest to myself. We do not have to use only one strategy in a problem; we can use different strategies to check the solution. After the problem solving course, I have realized that I could solve the problems by logical reasoning and intelligent guessing and testing strategies, while I used to solve them only with algebraic expressions. (PT7)

> I think the problem solving strategy is to think about how to solve a problem. It is a way, a method, to think about which ways to follow when solving a problem… I usually use the logical reasoning strategy. This is what we usually do when we have problems in daily life. I also use finding a pattern and working backwards strategies… I decide which strategy to use according to the structure of the problem. (PT1)

As a result of the interviews, most frequently used strategies by prospective mathematics teachers were determined as logical reasoning, finding a pattern, working backwards, solving a simpler analogous problem, making a drawing, intelligent guessing and testing and making a systematic list strategies. In addition, it was determined that it was effective in determining the strategy for solving a problem: (1) what is given and what is asked in the problem, (2) the structure of the problem, (3) the knowledge about the problem solving strategy and (4) ability to apply the strategy.

In this section, the problem solving processes of the prospective teachers will be examined with direct quotes from the written data. Below some examples are given of the problems and solutions that prospective teachers wrote before problem solving instruction.

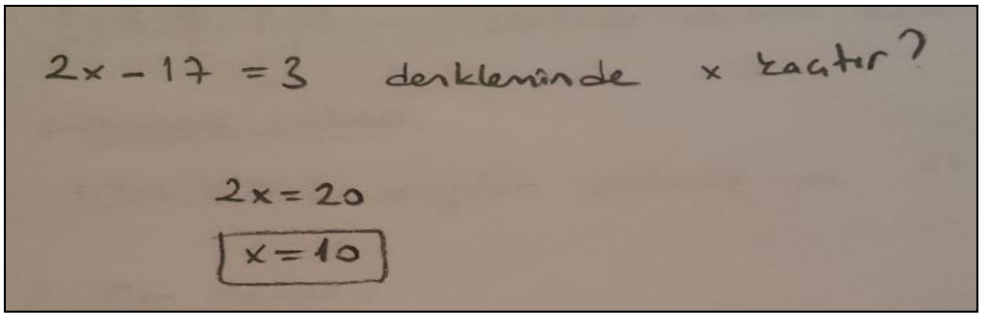


Figure 1. The Problem Written by PT8 Before Problem Solving Course

Before the problem solving instruction, PT8 wrote an equation as a problem, and solved it. PT8 made solution of the problem directly without following problem solving steps.

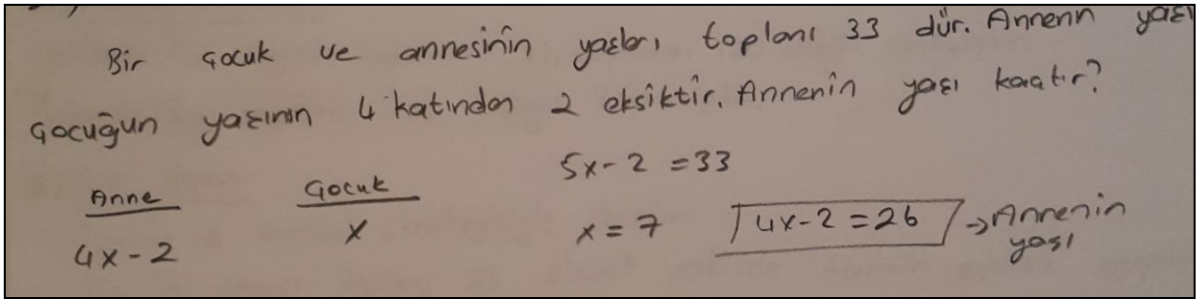


Figure 2. The Problem Written by PT6 Before Problem Solving Instruction

PT6 wrote an age problem and solved the problem by writing and solving an equation without following problem solving steps.

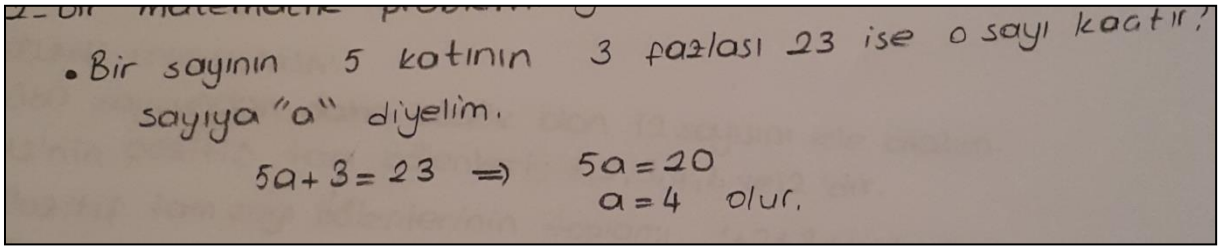


Figure 3. The Problem Written by PT25 Before Problem Solving Instruction

PT25 solved his problem by writing and solving an equation without following problem solving steps.

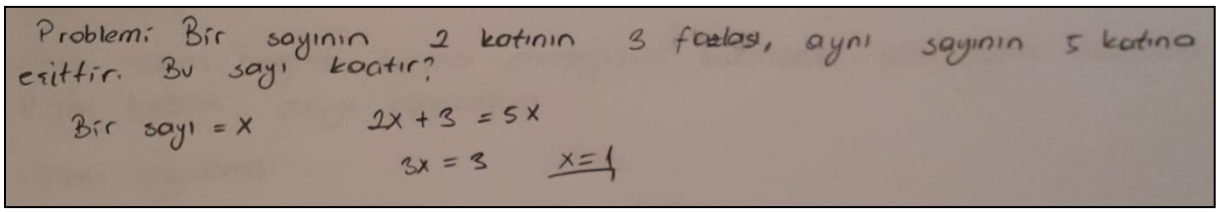


Figure 4. The Problem Written by PT20 Before Problem Solving Instruction

PT20 wrote a problem similar to PT25 and preferred to find the solution by writing and solving an equation without following problem solving steps.

As can be seen from the examples presented, the prospective teachers mostly wrote word problems requiring four operations and they solved the problems directly without following any problem solving step. They also solved the problems by writing and solving equations. Only two prospective teachers gave explanations for understanding the problem. The problems and solutions of these prospective teachers are presented below.

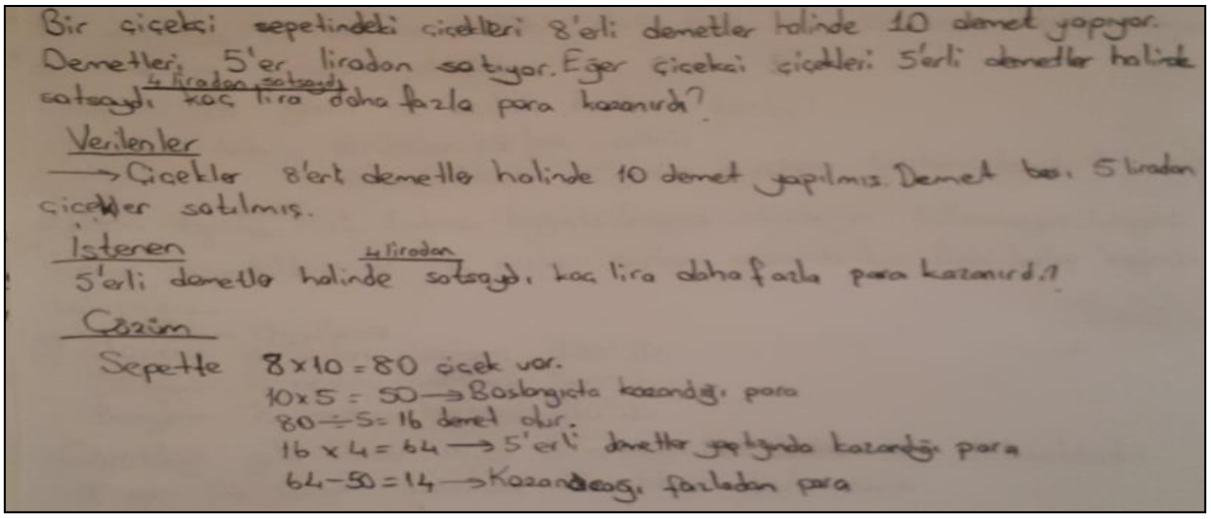


Figure 5. The Problem Written by PT2 before the Problem Solving Instruction

PT2 gave explanations about the understanding the problem while solving the problem they wrote before the *problem solving* course. Firstly, PT2 determined what is given and what is asked for the understanding the problem. Then, unlike most of the prospective teachers, PT2 solved the problem using calculations based on four operations without writing and solving equations.

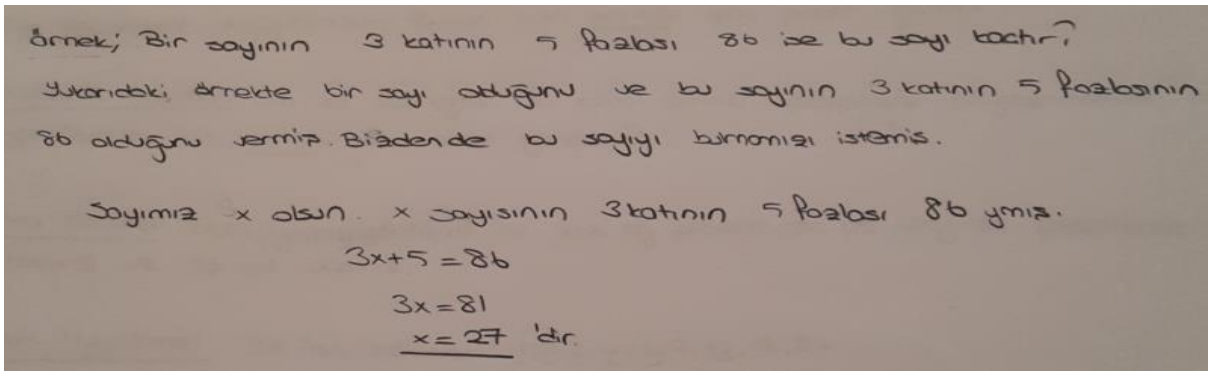
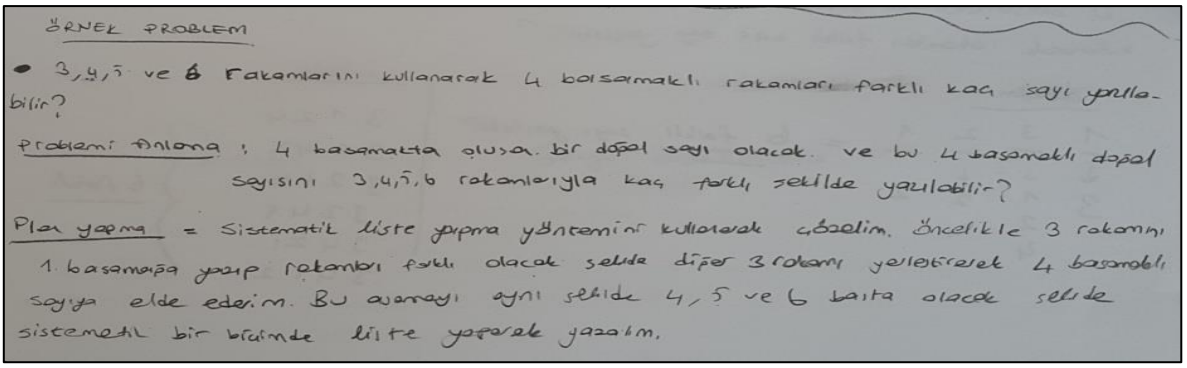


Figure 6. The Problem Written by PT29 Before Problem Solving Instruction

PT29 stated the problem in her own words and then solved the problem. He preferred writing and solving an equation to solve the problem.

Before the problem solving instruction, forming and solving equations were frequently used to solve problems. However, after the problem solving instruction, prospective teachers have realized that problem solving is a process. They also encountered the steps they needed to follow. As a result, they wrote problems that were appropriate for this process. The problem and solution of the problem written by PT13 at the end of the problem solving course are presented below step by step.


ÖRNEK PROBLEM

• 3,4,5 ve 6 rakamlarını kullanarak 4 basamaklı rakamları farklı kaç sayı yazılabilir?

Problemi anlama : 4 basamaklıda olusan bir doğal sayı olacak. ve bu 4 basamaklı doğal sayısını 3,4,5,6 rakamlarıyla kaç farklı şekilde yazılabilir?

Plan yapma = Sistematik liste yapma yöntemini kullanarak çözelim. Öncelikle 3 rakamını 1. basamağa yazıp rakamları farklı olacak şekilde diğer 3 rakamı yerleştirerek 4 basamaklı sayıya elde ederim. Bu aşamayı aynı şekilde 4, 5 ve 6 daha olacak şekilde sistematik bir biçimde liste yaparak yazalım.

Figure 7. Understanding the Problem and Devising a Plan Steps of Problem Solving Process of PT13 After the Problem Solving Instruction

The problem written by PT13: How many four digit numbers can be formed using digits 3, 4, 5, and 6, without repeating any digit?

PT13 solved the problem she wrote after the problem solving instruction by following the problem solving steps. In the step of understanding the problem, PT13 restated the problem in her own words. Then, she stated that she would use making a systematic list strategy. It also explained how to use the strategy in devising a plan step. In the process of understanding the problem, the student can state the problem with his / her own words, write the problem in summary, determine what is given and what is asked, and draw the appropriate drawings. Results of the study indicated that these critical behaviors were observed in the understanding the problem step in prospective teachers' problem solving processes after the problem solving instruction. In the process of understanding the problem, the prospective teachers mostly determined what is given and what is asked. In the problem solving process, the next step is devising a plan. In this step, it should be decided which strategy will be used to solve the problem and how the strategy will be implemented in the solution. It may be necessary to use more than one strategy to solve some problems. It would be appropriate to specify these strategies at planning process. According to results of the study, after the problem solving instruction, all prospective teachers explained the name of strategy and how to use this strategy in devising a plan step.

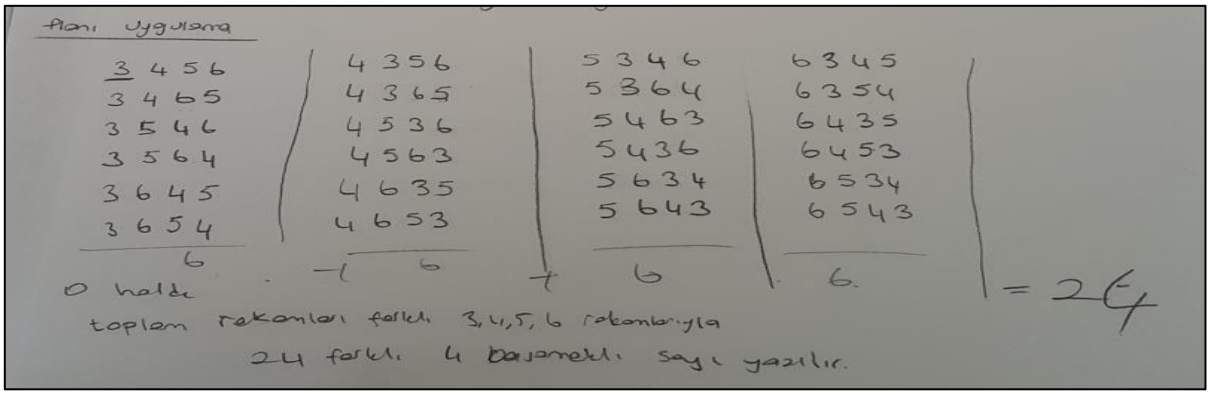


Figure 8. Carrying Out the Plan Step Applied by PT13

Carrying out the plan depends on the problem and the strategy. In this step, the prospective teachers applied the strategy and solved the problem. As seen in Figure 8, PT13 applied the plan by making a systematic list and listed all the situations with digits 3, 4, 5 and 6 in the thousands, respectively.

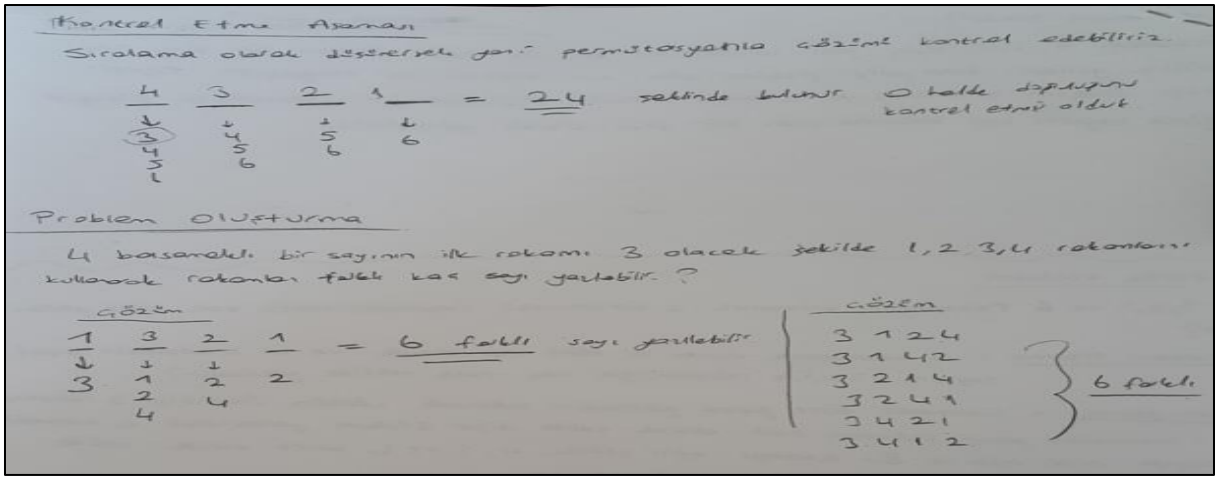


Figure 9. Checking/Looking Back and Posing a New Problem Steps Applied by PT13

After carrying out the plan, the solution should be checked. In the checking/looking back step, the check can be done in different ways. For example, sometimes the problem can be resolved with a different strategy; sometimes the person can try to reach what is given by working backwards from the result; or the logical consistency of the problem can be controlled (Baykul, 2014). Similarly, it can be checked each step during the problem solving process. PT13 checked the solution using permutation. Posing a new problem step requires writing a new problem without changing the context of the given problem completely. In Figure 9, the problem written by PT13 in posing a new problem step is presented.

According to the results of the study, the prospective mathematics teachers did not follow any problem solving process before the *problem solving* course; at the end of the problem solving course, it was determined that the majority of the prospective teachers followed the steps, understanding the problem, devising a plan, carrying out the plan, checking/looking back and posing a new problem. Findings also showed that the majority of the prospective elementary mathematics teachers wrote word problems including four arithmetic

operations before the *problem solving* course and solved their problems by writing and solving equations. However, after the problem solving course, they wrote different problems that could be solved with at least two strategies and they solved their problems by using at least two different strategies.

Opinions about Problem Solving Instruction

The prospective teachers stated that *problem solving* course made them a great contribution and increased their success and self-confidence. Similarly, they stated that they obtained a lot of experience and valuable knowledge which would be useful to them in profession of teaching. Examples of prospective teachers' opinions about problem solving instruction are presented below.

> I think that the problem solving course has changed the way of my thinking. We have learned not to solve a problem without understanding. I have learned to think more logically, to understand the problem and to follow the steps. Thanks to problem solving steps we have learned how to solve the problem and how to teach it to students. I think this course has contributed both learning and teaching of problem solving. I have learned to think of a problem from different perspectives. I have learned from what perspective I would look at the problems. I have learned how to approach students' learning. For example, I have learned that working backwards strategy was an effective strategy for students in concrete operational stage or students with difficulty in understanding algebraic expressions. (PT1)

> My thinking structure was influenced. Our brains develop better when we use different strategies and we learn to look at different perspectives. So, I think this course is important… The course also was enjoyable for me. I normally looked straight at most things, but my perspective has changed with this course. I saw that there could be more than one solution to a problem and that different ways (strategies) could be used. It was a good course. (PT2)

> Now, you understand the problems better. If you cannot solve the problem, you realize that you do not understand it. It is very useful to follow the (problem solving) process… I will teach my students by this way. They will understand better if I use the steps and strategies. (PT5)

> The course was enjoyable. Now, it is more important what we think and how a process to follow than answer of the problem. I will pay attention to this in my students… In the first lessons everyone was saying the answers of the problems. Now I think that the answer of the problem can be found anyway. For this reason, I should think how to progress. (PT6)

According to interview results, the prospective teachers thought that the problem solving course was enjoyable. The problem solving course has changed the prospective teachers' way of thinking. They started to give more importance to understanding the problem and to pay attention to problem solving steps. They also expressed satisfaction with learning different problem solving strategies. The results can

be related to the experiences gained in *problem solving* course by the prospective teachers who have learned the problem solving steps and strategies and found opportunities to apply them to different problems.

> This course influenced my way of thinking… It is useful. I did not know that the problems could be solved with strategies. We usually used the letter "x" to signify the unknown. After the problem solving course, I have learned the strategies and it is very nice. Similarly, I did not know that the problems could be solved step by step. This is a very nice thing; you realize why and how you solve the problem. (PT3)

> With the problem solving course, we realized that there was not only one correct solution way of a problem and that there were different ways to solve it. We usually used to solve problems without understanding the problem step, but now understanding the problem step has a permanent place in our minds. Now we try to understand and write what is given and what is asked. I have realized that: There is not a single solution to every problem; every problem has a solution; understanding is very important. Using different strategies is very important. We encountered different problems and learned to use different strategies. We have solved problems in only one way so far, but by learning other strategies we have learned that there were easier and more plausible solutions. This course was very effective. (PT4)

According to interview results, the prospective teachers stated that problem solving instruction was a useful instruction that influenced their thinking processes. They also stated that they have gained different, easy and plausible perspectives and realized the importance of understanding. It is thought that learning about different strategies in the *problem solving* course made it possible for the prospective teachers to realize that there were easy and reasonable problem solving strategies besides equations for solving the problem and increased the use of these strategies.

> My way of thinking was affected very much. Now I know better what I'm doing… Now I can better analyze in what stage students make a mistake… I used to solve the question before, to read the question again; I used to check arithmetic operations and to control the same process again and again but now I do not have any difficulty because I follow the steps to solve problems. Certainly I have improved (in problem solving) and it gives confidence to me. You do not look at it from a single perspective and you can look at it from many perspectives. This has been a valuable experience for me and for my friends as well… (PT7)

According to interview results, prospective teachers stated that the problem solving instruction affected their way of thinking, raised awareness about their own problem solving processes and students' mistakes in solving problems, and increased their self-confidence. It is believed that the experience gained in problem solving

instruction has increased prospective teachers' self-confidence by enabling them to analyze the problem solving process better.

DISCUSSION AND CONCLUSION

In this study, problem solving processes of prospective elementary mathematics teachers and how *problem solving* course affected their problem solving processes were examined. The opinions of the prospective mathematics teachers about the problem solving process and instruction were also determined.

The results of the research showed that before the *problem solving* course, the prospective teachers did not follow the problem solving process and had a limited knowledge about the problem solving process. Similarly, Labuda (2004) determined that teachers' knowledge about the problem solving process was very limited. In the present study, after the *problem solving* course, the prospective teachers have started to apply the problem solving steps explained to them. At the end of the study, it was determined that the majority of the prospective teachers followed the steps, understanding the problem, devising a plan, carrying out the plan, checking/looking back and posing a new problem. The results of the interviews supported these results and revealed that prospective teachers thought that it was useful and necessary to follow these steps in problem solving process. In addition, the results of the interviews indicated that the prospective teachers have realized the importance of understanding the problem after the problem solving instruction. The fact that many educators express understanding the problem as one of the main factors that affect problem solving makes the present finding meaningful (e.g., Cai, 2003; Jitendra, Griffin, Buchman and Sczesniak, 2007; Polya, 1973; Xin, 2007). Developing awareness of the importance of understanding can be considered as a positive contribution of problem solving instruction to prospective elementary mathematics teachers' problem solving process. Prospective teachers who realized the importance of understanding are expected to plan activities to help students build this awareness. The interview results also supported this thought. Prospective teachers stated that they would apply their knowledge obtaining during the problem solving instruction in profession of teaching.

The results of the study showed that the majority of the prospective elementary mathematics teachers wrote word problems including four arithmetic operations before the *problem solving* course and solved the problems they wrote by setting an equation. This result is consistent with the results of some other studies on problem posing and problem solving. For example, Korkmaz and Gür (2006) determined that prospective teachers mostly used word problems including four arithmetic operations when posing problems. In addition, Bayrakdar, Deniz, Akgün and İşleyen (2011) determined that prospective teachers' use of problem solving strategies was not at an adequate level but they could only use them adequately in situations where they need to find a formula, operation or pattern. In the current research, after the *problem solving* course, prospective teachers wrote problems that could be solved with at least two different strategies and solved them by using at least two different strategies. It is believed that the necessity of presenting problems enabling multiple solutions and different mathematical knowledge as a way of establishing a relationship among the information

to be used in the problem solving process (Leikin, 2007) makes this finding meaningful. Problem solving strategies used by prospective teachers in problem solving process were making a systematic list, working backwards, finding a pattern, making a drawing, logical reasoning, intelligent guessing and testing, and solving simpler analogous problem. The interviews with the prospective teachers supported these findings. Prospective teachers stated that they usually used to solve the problems with equations before the *problem solving* course but after the *problem solving* course they preferred to use different problem solving strategies since they have learned various problem solving strategies during the problem solving instruction. This result can be interpreted as prospective teachers tend to learn strategies and to apply what they learn. The finding related to strategy teaching and use in the present study is consistent with the results of some studies on problem solving. For example, Altun and Arslan (2006) reached the conclusion that after the 10-week strategy training for 7th and 8th grade students, problem solving strategies was substantially learned and used for problem solving. In addition, many research findings showed that teaching problem solving strategies was effective in improving problem solving ability (e.g., Arslan and Altun, 2007; Charles and Lester, 1984; Çalışkan, 2007; Lee, 1982; Schoenfeld, 1979). Therefore, it can be said that activities to teach problem solving strategies will contribute to the use of problem solving strategies in problem solving process.

Prospective teachers stated that they had difficulties in the first week of problem solving course in a new problem posing step which was the last stage of problem solving but they were satisfied with having experienced this process. Prospective teachers' difficulties in posing problems can result from having no experience of problem posing (Rizvi, 2004) or having limited experience or traditional problem solving experience (Chapman, 2012). Prospective teachers expressed that problem posing studies contributed to getting different perspectives, looking through the eyes of others and their professional knowledge. Similarly, some studies on problem posing mentioned positive effects of problem posing studies. For example, Toluk-Uçar (2009) suggested that problem posing studies had positive effects on prospective teachers on the understanding of fractions and views about meaning of knowing mathematics. Stoyanova (1998) argues that problem posing based mathematics instruction produces better problem solving performance than problem solving based mathematics instruction. Similarly, according to Schoenfeld (1985), in the problem posing based problem solving approach, studying on the problems that the students pose may result in a higher level of understanding of the problem. As a result, it can be said that problem solving instruction including problem posing may contribute positively to problem solving performance.

Prospective teachers stated that the problem solving instruction increased their success and self-confidence. Similarly, according to results, prospective teachers thought that in problem solving process, they obtained a lot of experience and valuable knowledge which would be useful to them in profession of teaching. Similarly, some studies emphasized positive contributions of teaching problem solving. For example, Çömlekoğlu (2001) found that prospective mathematics teachers and prospective classroom teachers had some misconceptions about mathematical problem concept and problem solving process and the application of problem solving with the calculator was positive effects on these misconceptions. In the present study, interviews with prospective

teachers give clues that learning about problem solving steps and strategies increases prospective teachers' self-confidence. Thompson (1989) reached a similar conclusion as a result of the research carried out with teachers and found that having sufficient knowledge about the problem solving process increased teachers' self-confidence in problem solving practices in their lessons. Therefore, it can be said that the teaching of the problem solving process is effective in improving prospective teachers' knowledge, experience and self-confidence in problem solving.

SUGGESTIONS

Based on the results of the present study, it is thought that the development of applications of problem solving methods and strategies for prospective teachers contribute positively to the development of problem solving skills. In this respect, problem solving courses should be added to teacher education programs.

With the results of the current study, it was determined that instruction of problem solving process increased prospective teachers' knowledge, experience and self-confidence. Similarly, prospective teachers expressed that during the problem solving instruction they have acquired a lot of experience and valuable knowledge which would be useful to them in profession of teaching. Thus, opportunities to learn problem solving steps and strategies should be provided prospective teachers to increase their knowledge and experience about problem solving, their problem solving achievements, their self-confidence and their professional knowledge, skills and experiences in teaching problem solving.

Considering the positive effects of the problem posing practices on prospective teachers' problem solving processes, problem posing practices should be designed to increase prospective teachers' knowledge and skills about problem posing. Since positive contribution of the problem solving instruction applied in the current study to the prospective teachers' problem solving processes was observed, the current study can be replicated with students and teachers to improve their problem solving processes.

TÜRKÇE GENİŞ ÖZET

PROBLEM ÇÖZME ÖĞRETİMİ: ÖĞRETMEN ADAYLARININ GÖRÜŞLERİ VE PROBLEM ÇÖZME SÜREÇLERİ

GİRİŞ

Gagne'ye (1980: 25) göre "eğitimin merkezi noktası insanlara düşünmeyi, zihinsel güçlerini kullanmayı ve daha iyi problem çözücüler olmayı öğretmektir". Bu doğrultuda, günümüzde matematik eğitiminde kâğıt-kalem ile hesaplamanın önemi giderek azalırken tahmin edebilme, problem çözme gibi beceriler önem kazanmaktadır (Talim ve Terbiye Kurulu Başkanlığı [TTKB], 2009).

Problem çözme önceden belirlenmiş rutin bir algoritmanın uygulanmasından çok daha fazlasını gerektiren bir süreçtir (Lester, 1994). Polya (1973) matematik problemlerini çözmede dört adım içeren bir çerçeve önermiştir. Bu adımlar; (1) problemi anlama, (2) çözüm için plan yapma, (3) planı uygulama ve (4) sonucu kontrol etmedir. Ortaokul matematik öğretim programı ise problem çözme becerilerini geliştirmede, (1) problemi anlama, (2) çözümü planlama, (3) planı uygulama, (4) çözümün doğruluğunu ve geçerliğini kontrol etme ve (5) çözümü genelleme ve benzer/özgün problem kurma süreçlerinin takip edilmesini önermektedir (TTKB, 2013). Araştırmalar problem çözme süreç ve davranışlarına yönelik öğretimin, problem çözme başarısını artırmada etkili olduğunu göstermektedir (örn., Altun, 1995; Arslan ve Altun, 2007; Charles ve Lester, 1984; Lee, 1982; Yıldız, 2008).

Hedefimiz öğrencilerin problem çözme becerilerini geliştirmek ise bu hedefi ancak öğretmenler aracılığıyla gerçekleştirebiliriz (Thompson, 1989). Öğretmenlerin alan ve mesleğe dair bilgi ve becerileri öğrenci başarısını etkileyen önemli bir faktördür (Ball, Thames ve Phelps, 2008; Franke ve Kazemi, 2001). Öğretmenlerin alan ve pedagojik alan bilgilerinin öğrencilerin öğrenme süreçleri üzerindeki etkilerine ilişkin alanyazında yer alan çalışmalar göz önüne alındığında, öğretmen adaylarının problem çözme becerilerini geliştirmek teşvik edilmelidir (Dooren, Verschaffel ve Onghena, 2003).

Matematiği öğrenmek; temel kavram ve becerilerin kazanılması ve matematiğin gerçek yaşamda önemli bir araç olduğunu fark etmenin yanı sıra matematikle ilgili düşünmeyi ve problem çözme stratejilerini kavramayı da içerir (TTKB, 2013). Bazı araştırmalar, problem çözme stratejilerinin öğretiminin problem çözme becerisini artırdığı sonucuna ulaşmıştır (örn., Arslan ve Altun, 2007; Charles ve Lester, 1984; Çalışkan, 2007; Lee, 1982; Schoenfeld, 1979). Bununla birlikte, problem çözme stratejilerinin öğretimi sadece matematiksel problemlere bakış açımızı değil günlük hayat problemlerine bakış açımızı da geliştirebilecek önemli bir gerekliliktir (Posamentier ve Krulik, 1998).

Bu çalışmanın temel amacı, ilköğretim matematik öğretmen adaylarının problem çözme süreçlerini incelemek ve problem çözme öğretiminin öğretmen adaylarının problem çözme sürecini nasıl etkilediğini belirlemektir.

Öğretmen adaylarının problem çözme süreci ve *problem çözme* dersi hakkındaki görüşlerini tespit etmek de çalışmanın amaçları arasındadır. Bu doğrultuda aşağıdaki problem ve alt problemlere cevap aranmıştır:

1. İlköğretim matematik öğretmen adaylarının problem çözme dersi öncesinde problem çözme süreçleri nasıldır?

1.1. Öğretmen adaylarının problem çözme dersi öncesinde problem çözerken takip ettikleri aşamalar nelerdir?

1.2. Öğretmen adaylarının problem çözme dersi öncesinde problem çözerken kullanmış oldukları problem çözme stratejileri nelerdir?

2. İlköğretim matematik öğretmen adaylarının problem çözme dersi sonrasında problem çözme süreçleri nasıldır?

2.1. Öğretmen adaylarının problem çözme dersi sonrasında problem çözerken takip ettikleri aşamalar nelerdir?

2.2. Öğretmen adaylarının problem çözme dersi sonrasında problem çözerken kullanmış oldukları problem çözme stratejileri nelerdir?

3. İlköğretim matematik öğretmen adaylarının problem çözme dersi hakkındaki görüşleri nelerdir?

YÖNTEM

Bu araştırma, ilköğretim matematik öğretmen adaylarının, problem çözerken kullandıkları aşamaları ve stratejileri ortaya çıkarmayı ve problem çözme sürecini geliştirmek için yapılan problem çözme öğretiminin bu sürece ne tür katkılarının olduğunu görüşme ve yazılı verileri inceleme yöntemleriyle belirlemeyi amaçlayan nitel bir çalışmadır. Çalışma sürecinin başında ve sonunda, öğretmen adaylarından bir problem kurup çözmeleri istenmiş ve çözümler yazılı olarak toplanmıştır. Bireylerin deneyim ve algılarına yönelik bilgi elde etmede oldukça etkili bir yöntem olması dolayısıyla (Briggs, 1986), problem çözme dersi sona erdikten sonra, gönüllü yedi öğretmen adayı ile görüşmeler gerçekleştirilmiştir.

Bu çalışmaya, 2016-2017 eğitim-öğretim yılı güz döneminde İç Anadolu Bölgesinde bulunan bir devlet üniversitesinin Eğitim Fakültesi İlköğretim Matematik Öğretmenliği Anabilim Dalı 3. sınıfta öğrenim gören ve "*Problem Çözme*" isimli seçmeli derse kayıtlı 36 öğretmen adayı (31 kız, 5 erkek) katılmıştır. Çalışmaya katılan 36 öğretmen adayından 7'si (4 kız, 3 erkek) ile görüşmeler gerçekleştirilmiştir. Görüşme yapılan öğretmen adayları gönüllülük esasına dayanarak belirlenmiştir.

Öğretmen adaylarının problem çözme süreçlerini ve bu sürece problem çözme öğretiminin etkisini incelemek amacıyla, 14 haftalık (28 ders saati) *problem çözme* dersinin ilk haftasında ve ders tamamlandıktan sonra, öğretmen adaylarından bir problem kurup, kurdukları problemi çözmeleri istenmiş ve çözümler yazılı olarak toplanmıştır.

Ders kapsamına geriye doğru çalışma, bağıntı bulma, çizim yapma (görsel temsil), sistematik liste yapma, benzer basit problemlerin çözümünden yararlanma, tahmin ve kontrol etme ve mantıksal muhakeme stratejileri dâhil edilmiştir (Baykul, 2014; Posamentier ve Krulik, 1998). Problem çözme sürecinde, Polya'nın (1973) dört adımlı problem çözme sürecine "problem yazma" adımı eklenerek beş basamaklı süreç uygulanmaya teşvik edilmiştir. Problem kurma belirli koşullar altında problem oluşturulmasını içerebileceği gibi üzerinde çalışılan problemlerin değiştirilmesiyle yeni problemler elde edilmesini de kapsamaktadır (Silver, 1994). Mevcut çalışmada, problem kurma aşamasında öğretmen adayından üzerinde çalıştığı problemden yeni bir problem oluşturması istenmiştir.

Görüşmelerde, öğretmen adaylarının problem çözme süreci ve öğretimi hakkındaki görüşlerini ortaya çıkarmaya yönelik olarak sekiz adet açık uçlu sorudan oluşan görüşme formu kullanılmıştır. Görüşme formu, görüşme amacına uygun olarak öğretmen adaylarından derinlemesine bilgi elde etmeye yönelik sorular içermektedir.

Araştırmada odaklanılan soruların cevaplandırılmasına yönelik olarak, veriler betimsel analiz yöntemiyle incelenmiştir. Bu tür analizde, veriler araştırma sorularının ortaya koyduğu temalar ya da görüşme ve gözlem süreçlerinde kullanılan sorular/boyutlar aracılığıyla sunulabilir (Yıldırım ve Şimşek, 2006).

Veri analizinde, öncelikle yazılı veriler, problem çözme aşamaları ve problem çözme stratejileri temaları altında incelenerek, öğretmen adaylarının problem çözme öğretimi öncesindeki ve sonrasındaki problem çözme süreçleri belirlenmiştir. Daha sonra, problem çözme dersi sonunda yapılan görüşmeler, öğretmen adaylarının problem çözme süreci ve öğretimi hakkındaki görüşlerini incelemek üzere problem çözme aşamaları, problem çözme stratejileri ve problem çözme öğretimi hakkındaki görüşler temaları altında incelenmiştir. Belirlenen tema ve alt temalar kapsamında "görüş birliği" ve "görüş ayrılığı" olan konular tartışılmış; verilerin "problem çözme süreci" ve "problem çözme dersi hakkındaki görüşler" temaları altında sunulması kararlaştırılarak gerekli düzenlemeler yapılmıştır.

BULGULAR

Bulgular öğretmen adaylarının problem çözme dersi öncesi izledikleri belirgin bir sürecin olmadığını fakat ders sonrası kendi yazmış oldukları problemleri çözerken büyük çoğunluğunun, problemi anlama, çözüm için plan yapma, planı uygulama, sonucu kontrol etme ve yeni bir problem kurma süreçlerini takip ettiklerini göstermiştir. Ayrıca görüşmelerin analizi, öğretmen adaylarının problem çözme sürecinde bu adımların takip edilmesinin yararlı ve gerekli olduğunu düşündüklerini ortaya çıkarmıştır.

Problem çözme dersi sonunda öğretmen adayları ile yapılan görüşmelerde, öğretmen adayları herhangi bir problemle ilk karşılaştıklarında yapacaklarını, anlamaya çalışma, benzer problemlerle karşılaşıp karşılaşmadığını sorgulama ve çözüm yolunu düşünme olarak belirtmiştir.

Görüşmelere katılan öğretmen adaylarının tamamı problem çözme sürecinde problem çözme aşamalarının takip edilmesinin önemli olduğunu ve problem çözme sürecindeki önemli noktaların başında anlamanın geldiğini ifade etmişlerdir.

Öğretmen adayları problemi anlamada problemde geçen kavramları anlamanın da önemli olduğunu, problemdeki kavram karmaşasının problemi anlamayı olumsuz etkileyebileceğini belirtmişlerdir.

Öğretmen adayları, problem çözmenin son aşaması olan yeni bir problem yazma adımında, problem çözme dersinin ilk haftalarında zorlandıklarını ama bu süreci deneyimlemiş olmaktan memnun olduklarını ifade etmişlerdir. Öğretmen adayları ile yapılan görüşmeler, problem kurma çalışmalarının öğretmen adaylarının düşünce yapılarını etkilediği, problemlere yönelik farklı bakış açıları geliştirmeye, problemlere başkalarının gözünden bakabilmeye ve mesleki bilgilerine katkı sağladığını ortaya çıkarmıştır.

Problem çözme dersi öncesinde toplanan yazılı verilerden elde edilen bulgular 32 öğretmen adayının (%88,89) yazdıkları problemleri denklem kurarak çözdüklerini ya da doğrudan denklem çözümünü soran sorular yazdıklarını göstermiştir. Sadece dört öğretmen adayı (%11,11) yazdığı problemi denklem kurmadan dört işleme dayalı temel işlem bilgisini kullanarak çözmüştür.

Problem çözme dersi sonrasında toplanan yazılı verilere göre ise öğretmen adayları kendi yazdıkları problemleri en az iki farklı strateji kullanarak çözmüşlerdir. Öğretmen adaylarının yazdıkları problemleri çözerken kullandıkları stratejiler, sistematik liste yapma (%30,6), geriye doğru çalışma (%19,4), bağıntı bulma (%13,9), çizim yapma (%13,9), mantıksal muhakeme (%8,3), tahmin ve kontrol etme (%8,3) ve benzer basit problemlerin çözümünden yararlanma (%2,8) stratejileridir. Bir öğretmen adayı ise problemini dört işleme dayalı temel işlem bilgisini kullanarak çözmüştür. Öğretmen adayları çözümün kontrolü aşamasında problemi farklı bir yoldan tekrar çözmüşlerdir. Problemin kontrol aşamasında dokuz öğretmen adayının denklemlerden yararlandığı belirlenmiştir.

Sonuç olarak, öğretmen adaylarının problem çözme dersi öncesinde herhangi bir problem çözme sürecini takip etmediği; problem çözme dersi sonunda ise büyük çoğunluğunun anlama, plan yapma, planı uygulama, kontrol etme ve yeni bir problem yazma aşamalarını içeren bir süreç takip ettiği belirlenmiştir. Bulgular, problem çözme dersi öncesinde öğretmen adaylarının çoğunluğunun dört işlem gerektiren sözel problemler yazdıklarını ve problemlerini denklem kurarak çözdüklerini; bununla birlikte problem çözme dersi sonrasında en az iki strateji ile çözülebilecek farklı problemler yazıp çözümlerini de en az iki farklı strateji kullanarak yaptıklarını göstermiştir. Ayrıca, öğretmen adayları problem çözme dersinin kendilerine büyük katkı sağladığını, problem çözme dersinde öğrendiklerini uygulayarak başarılarının ve özgüvenlerinin arttığını, düşünce yapılarının etkilendiğini ayrıca öğretmenlik mesleğinde kendilerine çok yararlı olacağını düşündükleri bilgi ve deneyimler edindiklerini belirtmişlerdir.

TARTIŞMA VE SONUÇ

Araştırma sonuçları, problem çözme dersi öncesinde öğretmen adaylarının problem çözme sürecinde problem çözme adımlarını takip etmediğini ve problem çözme süreci ile ilgili kısıtlı bir bilgiye sahip olduklarını göstermiştir. Problem çözme dersi sonrasında, öğretmen adayları kendilerine anlatılmış olan problem çözme adımlarını uygulamaya başlamışlardır. Çalışma sonunda, öğretmen adaylarının büyük çoğunluğunun kendi yazdıkları problemleri çözerken problemi anlama, çözüm için plan yapma, planı uygulama, kontrol etme ve yeni bir problem yazma aşamalarını takip ettiği belirlenmiştir. Problem çözme öğretimi sonrasında öğretmen adayları ile yapılan görüşmeler bu sonucu destekler nitelikte olup, öğretmen adaylarının düşüncesi bu adımları içeren problem çözme sürecini takip etmenin gerekli ve önemli olduğu yönündedir. Ayrıca görüşmeler, öğretmen adaylarının problem çözme öğretimi sonrasında problemi anlamanın öneminin farkına vardıklarını ortaya çıkarmıştır. Anlamanın önemini kavrayan öğretmen adaylarının öğrencilerine de bu farkındalığı kazandırmaya yönelik etkinlikler planlayacağı düşünülmektedir. Görüşmelerde öğretmen adaylarının öğrendiklerini mesleklerinde uygulayacaklarını belirtmiş olmaları bu fikri destekler niteliktedir.

Araştırmanın bulguları, problem çözme öğretimi öncesinde öğretmen adaylarının büyük çoğunluğunun dört işlem gerektiren sözel problemler kurduklarını ve yazdıkları problemleri denklem kurarak çözdüklerini göstermiştir. Problem çözme dersi sonrasında ise, öğretmen adayları en az iki farklı strateji ile çözülebilecek problemler yazmış ve farklı stratejiler kullanarak çözmüşlerdir. Problem çözme sürecinde kullanılacak bilgiler arasında ilişki kurmanın bir yolu olarak, farklı çözüm yolları ve farklı matematiksel bilgilerin kullanılmasını sağlayan birden çok çözüm yoluna açık problemlerin sunulması gerekliliğinin (Leikin, 2007), bu bulguyu anlamlı kıldığı düşünülmektedir. Öğretmen adaylarının problem çözerken kullandıkları stratejiler, sistematik liste yapma, geriye doğru çalışma, bağıntı bulma, çizim yapma, mantıksal akıl yürütme, tahmin ve kontrol etme ve benzer basit problemlerin çözümünden yararlanma stratejileri olarak belirlenmiştir. Öğretmen adayları ile yapılan görüşmeler bu bulguları destekler nitelikte olup, görüşmelerde öğretmen adayları problem çözme öğretimi öncesinde problemleri denklem kurarak çözmeye yatkın olduklarını fakat problem çözme öğretimi ile farklı stratejiler öğrendikleri için artık bunları kullanmayı tercih ettiklerini belirtmişlerdir. Bu sonuç öğretmen adaylarının stratejileri öğrenme ve öğrendiklerini uygulama eğiliminde oldukları yönünde yorumlanabilir.

Öğretmen adayları, problem çözme dersinin ilk haftalarında problem kurma sürecinde zorlandıklarını belirtmekle birlikte bu süreci deneyimledikleri için memnun olduklarını belirtmişlerdir. Öğretmen adaylarının problem kurmada zorlanmaları, problem kurma deneyimine sahip olmamalarına (Rizvi, 2004) ya da kısıtlı deneyime veya geleneksel problem çözme deneyimine sahip olmalarına (Chapman, 2012) bağlanabilir. Öğretmen adayları, problem kurma çalışmalarının farklı bakış açıları geliştirmeye, başkalarının gözünden problemlere bakabilmeye ve mesleki bilgilerine katkısı olduğunu belirtmişlerdir. Sonuç olarak, problem kurmayı da içeren problem çözme öğretiminin bireylerin problem çözme performanslarına olumlu yönde katkısı olacağı söylenebilir.

Öğretmen adayları, problem çözme öğretiminin kendilerine büyük katkı sağladığını, problem çözme öğretimi ile öğrendiklerini uygulayarak başarılarının ve özgüvenlerinin arttığını, düşünce yapılarının etkilediğini ayrıca

öğretmenlik mesleğinde kendilerine çok yararlı olacağını düşündükleri bilgi ve deneyimler edindiklerini belirtmişlerdir. Mevcut çalışmada öğretmen adayları ile yapılan görüşmeler, problem çözme adımlarını ve stratejilerini öğrenmiş olmanın öğretmen adaylarının özgüvenlerini artırdığının ipuçlarını vermektedir. Dolayısıyla, problem çözme sürecine yönelik öğretimin öğretmen adaylarının problem çözmeye yönelik bilgi, deneyim ve özgüvenlerini geliştirmede etkili olduğu söylenebilir.

ÖNERİLER

Mevcut araştırmanın sonuçları göz önüne alındığında öğretmen, öğretmen adayı ve öğrencilere yönelik problem çözme yöntemi ve stratejileri uygulamalarının geliştirilmesinin, araştıran, sorgulayan, eleştirel bakabilen ve problem çözebilen bireylerin yetiştirilmesine olumlu katkı sağlayacağı düşünülmektedir.

Mevcut çalışma sonuçları ile problem çözme sürecine yönelik öğretimin öğretmen adaylarının bilgi, deneyim ve özgüvenlerini artırdığı belirlenmiştir. Benzer şekilde, öğretmen adayları, problem çözme öğretiminin öğretmenlik mesleğinde kendilerine çok faydalı olacak bilgi ve deneyimler edindirdiğini ifade etmişlerdir. Elde edilen sonuçlar göz önüne alındığında, öğretmen adaylarına, problem çözme ile ilgili bilgi ve deneyimlerini, problem çözme başarılarını, özgüvenlerini ve problem çözme öğretimine yönelik mesleki bilgi, beceri ve deneyimlerini arttırmaya yönelik olarak problem çözme aşamalarının ve stratejilerinin öğretimini içeren öğrenme ortamlarının sunulması önerilmektedir.

Mevcut araştırma sonucu elde edilen problem kurma çalışmalarının olumlu etkileri düşünüldüğünde öğretmen adaylarının problem kurma ile ilgili bilgi ve becerilerini artırmaya yönelik uygulamaların yapılması önerilmektedir. Uygulanan problem çözme öğretiminin öğretmen adaylarının problem çözme sürecine olumlu katkısı gözlendiği için, mevcut çalışmanın öğrenci ve öğretmenlerin problem çözme sürecini geliştirmeye yönelik tekrarı önerilebilir.

Anahtar Kelimeler: Problem çözme süreci, problem çözme öğretimi, öğretmen adayı.

REFERENCES

Altun, M. (1995). *İlkokul 3, 4 ve 5. sınıf öğrencilerinin problem çözme davranışları üzerine bir çalışma*. Yayınlanmamış Doktora Tezi, Hacettepe Üniversitesi, Ankara.

Altun, M. ve Arslan, Ç. (2006). "İlköğretim öğrencilerinin problem çözme stratejilerini öğrenmeleri üzerine bir çalışma." *Uludağ Üniversitesi Eğitim Fakültesi Dergisi*, *XIX*(1): 1–21.

Arslan, Ç. (2002). *İlkoğretim yedinci ve sekizinci sınıf öğrencilerinin problem çözme stratejilerini kullanabilme düzeyleri üzerine bir çalışma*. Yayınlanmamış Yüksek Lisans Tezi, Uludağ Üniversitesi, Bursa.

Arslan, Ç. & Altun, M. (2007). "Learning to solve non-routine mathematical problems." *Elementary Education Online, 6*(1): 50–61.

Ay, Z.S. & Bulut, S. (2014). "Experimental study on mathematical problem solving approach with pre-service elementary teachers." *Pamukkale Üniversitesi Eğitim Fakültesi Dergisi, 36*: 45–57.

Aydoğdu, M. ve Ayaz, M. F. (2008). "Matematikte öğrencilere problem çözme yeteneğinin kazandırılması." E-*Journal of New World Sciences Academy, 3*(4): 588–596.

Ball, D. L., Thames, M. H., & Phelps, G. C. (2008). "Content knowledge for teaching: What makes it special?" *Journal of Teacher Education*, *59*(5): 389–407.

Baykul, Y. (2014). *Ortaokulda matematik öğretimi (5-. Sınıflar)*. Ankara: Pegem Akademi.

Bayrakdar, Z., Deniz, D., Akgün, L., & İşleyen, T. (2011). "Problem solving approaches of mathematics teacher candidates in PISA 2003." *Procedia Social and Behavioral Sciences*, *15*: 3334–3337.

Briggs, C. (1986). *Learning how to ask: A sociolinguistic appraisal of the role of the interview in social science research*. Cambridge University Press.

Cai, J. (2003). "Singaporean students' mathematical thinking in problem solving and problem posing: An exploratory study." *International Journal of Mathematical Education in Science and Technology*, *34*(5): 719–737.

Cankoy, O. ve Darbaz, S. (2010). "Problem kurma temelli problem çözme öğretiminin problemi anlama başarısına etkisi." *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi, 38*: 11–24.

Çalışkan, S. (2007). *Problem çözme stratejileri öğretiminin fizik başarısı, tutumu, özyeterliği üzerindeki etkileri ve strateji kullanımı.* Yayınlanmamış Doktora Tezi, Dokuz Eylül Üniversitesi, İzmir.

Chapman, O. (2012). "Prospective elementary school teachers' ways of making sense of mathematical problem posing." *PNA*, *6* (4): 135–146.

Charles R. & Lester, F. (1982). *Teaching problem solving: What, why and how*. Palo Alto, CA: Dale Seymour Publications.

Charles, R. I., & Lester, F. K. (1984). "An evaluation of a process-oriented instructional program in mathematical problem solving in grades 5 and 7." *Journal for Research in Mathematics Education, 15*(1): 15–34.

Crespo, S. (2003). "Learning to pose mathematical problems: Exploring changes in teachers' practices." *Educational Studies in Mathematics*, *52:* 243–270.

Çömlekoğlu, G. (2001). *Öğretmen adaylarının problem çözme becerilerine hesap makinesinin etkisi*. Yayınlanmamış Yüksek Lisans Tezi, Balıkesir üniversitesi, Balıkesir.

Dede, Y. (2004). "Öğrencilerin cebirsel sözel problemleri denklem olarak yazarken kullandıkları çözüm stratejilerinin belirlenmesi." *Educational Science and Practice, 4*(6): 175–192.

Dede, Y. ve Yaman, S. (2005). "Matematik öğretmen adaylarının matematiksel problem kurma ve problem çözme becerilerinin belirlenmesi." *Eğitim Araştırmaları, 5*: 41–56.

Demircioğlu, H., Argün, Z., & Bulut, S. (2010). "A case study: Assessment of preservice secondary mathematics teachers' metacognitive behaviour in the problem-solving process." *ZDM Mathematics Education, 42*: 493–502.

Dooren, W. V., Verschaffel, L., & Onghena, P. (2003). "Pre-service teachers' preferred strategies for solving arithmetic and algebra word problems." *Journal of Mathematics* Teacher Education, *6*: 27–52.

English, L. D. (2003). Problem posing in elementary curriculum. In F. Lester, & R. Charles (Eds.), *Teaching mathematics through problem solving*. Reston, Virginia: National Council of Teachers of Mathematics.

Franke, M. L., & Kazemi, E. (2001). "Learning to teach mathematics: Focus on student thinking." *Theory into Practice*, 40(2): 102–109.

Gagne, R. M. (1980). *The conditions of learning*. New York: Holt, Rinehart, & Winston.

Gonzales, N. A. (1998). "A Blueprint for Problem Posing." *School Science & Mathematics*, *9*(8): 448–456.

Harskamp E., & Suhre C. (2007). "Schoenfeld's problem solving theory in a student controlled learning environment." *Computers & Education, 49*: 822–839.

Herr, T., & Johnson K. (1994). *Problem solving strategies: Crossing the river with dogs*. USA: Key Curriculum Press.

Higgins, K. M. (1997). "The effect of long instruction in mathematical problem solving on middle school students' attitudes, beliefs and abilities." *Journal of Experimental Education, 66*(1): 5–24.

Işık, C. ve Kar, T. (2012). "Sınıf öğretmeni adaylarının problem kurma becerileri." *Mehmet Akif Ersoy Üniversitesi Eğitim Fakültesi Dergisi, 12*(23): 190–214.

Jitendra, A. K., Griffin, C. C., Buchman, A. D., & Sczesniak, E. (2007). "Mathematical problem solving in third-grade classrooms." *The Journal of Educational Research*, 100(5): 282–302.

Jonassen, D. H. (2000). "Toward a design theory of problem solving." *Educational Technology Research and Development,* 48(4): 63–85.

Kayaaslan, A. (2006). *İlköğretim 4. ve 5. sınıf öğrencilerinin matematiğin doğası ve matematik öğretimi hakkındaki inançları*. Yayınlanmamış Yüksek Lisans Tezi, Gazi Üniversitesi, Ankara.

Kayan, F. ve Çakıroğlu, E. (2008). "İlköğretim matematik öğretmen adaylarının problem çözmeye yönelik inançları." *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi*, *35*: 218–226.

Kılıç, Ç. (2013). "Sınıf öğretmeni adaylarının farklı problem kurma durumlarında sergilemiş oldukları performansın belirlenmesi." *Kuram ve Uygulamada Eğitim Bilimleri, 13*(2): 1195–1211.

Kılıç, Ç. (2014). "Sınıf öğretmenlerinin problem kurmayı algılayış biçimlerinin belirlenmesi." *Kastamonu Eğitim Dergisi, 22*(1): 203–214.

Kilpatrick, J. (1987). Problem formulating: Where do good problems come from? In Schoenfeld, A. H. (Ed.). *Cognitive Science and Mathematics Education* (pp. 123–147). NJ, Lawrence Erlbaum.

Korkmaz, E. ve Gür, H. (2006). "Öğretmen adaylarının problem kurma becerilerinin belirlenmesi." *Balıkesir Üniversitesi Fen Bilimleri Enstitüsü Dergisi*, *8* (1): 64–74.

Labuda, C. B. (2004). *The impact of a professional development program on the implementation of problem-solving strategies in the classroom*. Yayınlanmamış Doktora Tezi, University of Houston, Houston, USA.

Lee, S. K. (1982). "Fourth graders' heuristic problem-solving behavior." *Journal for Research in Mathematics Education*, *13*(2): 110–123.

Leikin, R. (2007). *Habits of mind associated with advanced mathematical thinking and solution spaces of mathematical tasks*. Proceedings of the Fifth Conference of the European Society for Research in Mathematics Education. University of Cyprus, Larnaca, Cyprus.

Lester, F. K. (1994). "Musings about mathematical problem solving research: 1970-1994." *Journal for Research in Mathematics Education*, *25*(6): 660–675.

Lin, P. J. (2004). Supporting teachers on designing problem-posing tasks as a tool of assessment to understand students' mathematical learning. In M. J. Hoines & A. B. Fuglestad (Eds.), Proceedings of the 28th Conference of the International Group for the Psychology of Mathematics Education, Vol. 3 (pp. 257–264). July 14-18. Bergen University College.

MEB (2016a). *PISA 2015 Ulusal Raporu*. Ankara: Milli Eğitim Bakanlığı Ölçme, Değerlendirme ve Sınav Hizmetleri Genel Müdürlüğü.

MEB (2016b). *TIMSS 2015 Ulusal Matematik ve Fen Ön Raporu*. Ankara: Milli Eğitim Bakanlığı Ölçme, Değerlendirme ve Sınav Hizmetleri Genel Müdürlüğü.

NCTM (2000). *Principles and standards for school mathematics*, Reston, VA: National Council of Teachers of Mathematics Pub.

Miles, M. B. & Huberman, A. M. (1994). *Qualitative data analysis*. Thousand Oaks, CA: Sage Publication.

Patton, M. Q. (1987). *How to use qualitative methods in evaluation*. Newbury Park, CA: Sage.

Phye, G. D. (2001). "Problem-solving instruction and problem-solving transfer: The correspondence issue." *Journal of Educational Psychology*, *93*(3): 571-578.

Polya, G. (1973). *How to solve it: A new aspect of mathematical method*. Princeton, NJ: Princeton University Press.

Posamentier, A. S., & Krulik, S. (1998). *Problem-solving strategies for efficient and elegant solutions*. California: Corwin Press.

Posluoğlu, Z. Y. (2002). *İlkoğretim matematik dersinde problem çözme becerisinin kazandırılmasında işbirliğine dayalı öğrenme yaklaşımının etkililiği*. Yayınlanmamış Yüksek Lisans Tezi, Gazi Üniversitesi, Ankara.

Reys, R., Suydam, M., Lindquist, M., & Smith, N. (1998). *Helping children learn mathematics (5th ed).* Boston: Allyn and Bacon.

Rizvi, N. F. (2004). "Prospective teachers' ability to pose word problems." International *Journal for Mathematics Teaching and Learning*, *12*: 1-22.

Schoenfeld, A. H. (1979). "Explicit heuristic training as a variable in problem-solving performance." *Journal for Research in Mathematics Education*, *10*(3): 173-187.

Schoenfeld, A. (1985). *Mathematical problem solving*. New York: Academic Press.

Schoenfeld, A.H. (1992). Learning to think mathematically: Problem solving, metacognition, and sense making in mathematics. In D.A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 334-368). New York, NY: Macmillan.

Silver, E. A. (1994). "On mathematical problem solving." *For the Learning of Mathematics*. 14(1): 19-28.

Soylu, Y. ve Soylu, C. (2006). "Matematik derslerinde başarıya giden yolda problem çözmenin rolü." *İnönü Üniversitesi Eğitim Fakültesi Dergisi*, *7*(11): 97-111.

Stoyanova, E. (1998). Problem posing in mathematics classrooms, In A. McIntosh & N. Ellerton (Eds), *Research in Mathematics Education: A contemporary perspective* (pp. 164-185). Edith Cowan University: MASTEC.

Tertemiz, N. ve Sulak, S. E. (2013). "İlköğretim beşinci sınıf öğrencilerinin problem kurma becerilerinin incelenmesi." *İlköğretim Online, 12*(3): 713-729.

Thompson, A. G. (1989). Learning to teach mathematical problem solving: Changes in teacher's conceptions and beliefs. In R. I. Charles & E. A. Silver (Eds.), *Research Agenda for Mathematics Education Vol 3* (pp. 232-243). *The Teaching and Assessing of Mathematical Problem Solving*. Reston, VA: Lawrence Erlbaum & National Council of Teachers of Mathematics.

Toluk-Uçar, Z. (2009). "Developing pre-service teachers understanding of fractions through problem posing." *Teaching and Teacher Education*, *25*: 166-175.

Toptaş, V. ve Gözel, E. (2017). " Sınıf öğretmeni adaylarının özyeterlik İle matematiksel problem çözmeye yönelik inançları.", Kırıkkale Üniversitesi Sosyal Bilimler Dergisi, 7(2): 439-460.

TTKB (2009). *İlköğretim matematik dersi 1.-5. sınıflar öğretim programı*. Ankara: Milli Eğitim Bakanlığı.

TTKB (2013). *Ortaokul matematik dersi (5, 6, 7 ve 8. Sınıflar) öğretim programı*. Ankara: Milli Eğitim Bakanlığı.

Turhan, B. ve Güven, M. (2014). "Problem kurma yaklaşımıyla gerçekleştirilen matematik öğretiminin problem çözme başarısı, problem kurma becerisi ve matematiğe yönelik görüşlere etkisi." *Çukurova Üniversitesi Eğitim Fakültesi Dergisi, 43*(2): 217-234.

Xin, P. Y. (2007). "Word problem solving tasks in textbooks and their relation to student performance." *The Journal of Educational Research*, 100(6): 347-359.

Yazgan, Y. (2007). "Dördüncü ve beşinci sınıf öğrencilerinin rutin olmayan problem çözme stratejileriyle İlgili gözlemler." *İlköğretim Online, 6*(2): 249-263.

Yıldırım, A. ve Şimşek, H. (2006). *Sosyal bilimlerde nitel araştırma yöntemleri*. (6. Baskı) Ankara: Seçkin Yayıncılık.

Yıldız, V. (2008). *Investigation of the change in sixth grade students' problem solving abilities, attitude towards problem solving and attitude toward mathematics after mathematics instruction based on Polya's problem solving steps.* Yayınlanmamış Yüksek Lisans Tezi, Orta Doğu Teknik Üniversitesi, Ankara.