INVESTIGATION OF THE EFFECTS OF PROBLEM SOLVING INSTRUCTION ON FIFTH GRADE STUDENTS' MATHEMATICAL PROBLEM SOLVING PERFORMANCE

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ABSTRACT

INVESTIGATION OF THE EFFECTS OF PROBLEM SOLVING INSTRUCTION ON FIFTH GRADE STUDENTS' MATHEMATICAL PROBLEM SOLVING PERFORMANCE

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The primary purpose of the current study was to investigate the effects of problem solving instruction on 5th grade students' mathematical problem solving performance across the three time periods. Also, the other aim of the study was to examine the relationship between 5th grade students' mathematical problem solving performance scores of Well-Structured Problem Solving Tests (WSPST) and Ill-Structured Problem Solving Tests (ISPST) after the problem solving instruction. In addition to that, exploring students' thoughts about problem solving instruction was another purpose of the current study.

The study was implemented in one private school in Niğde in the spring semester of the 2020-2021 academic year. The participants were thirty one 5th grade students in a private school. After implementing pretests, Problem Solving Instruction (PSI) based on Polya's idea was implemented during the fourteen class hours. Data were

collected separately from the ISPST and WSPST, which were applied as pretests, posttests, and retention tests.

One Way Repeated Measures ANOVA showed that the statistically significant change was observed in students' mathematical problem solving performance scores for both ISPST and WSPST across the three time periods at 0.05 level. Pearson Product-Moment Coefficient of Correlation results showed a strong positive correlation between problem solving scores of posts and retentions of ISPST and WSPST at 0.05 significance level. Moreover, views about the problem solving method questionnaire revealed that PSI left positive impressions on 5^{th} grade students. Future studies using qualitative or mixed methods can be conducted to examine the effect of PSI on mathematical problem solving performance in more depth.

Keywords: Problem Solving, Mathematical problem solving performance, Well-Structured Problem, Ill-Structured Problem, Polya's Problem Solving Stages

ÖZ

PROBLEM ÇÖZME ÖĞRETİMİNİN BEŞİNCİ SINIF ÖĞRENCİLERİNİN MATEMATİKSEL PROBLEM ÇÖZME PERFORMANSINA ETKİLERİNİN İNCELENMESİ

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Bu çalışmanın temel amacı, problem çözme öğretiminin 5. sınıf öğrencilerinin matematiksel problem çözme performansları üzerindeki etkilerini üç zaman diliminde araştırmaktır. Ayrıca araştırmanın bir diğer amacı da 5. sınıf öğrencilerinin problem çözme öğretimi sonrası iyi yapılandırılmış problem çözme testleri (WSPST) ile yarı yapılandırılmış problem çözme testleri (ISPST) sonuncunda elde ettikleri matematiksel problem çözme performans puanları arasındaki ilişkiyi incelemektir. Buna ek olarak, öğrencilerin problem çözme öğretimi hakkındaki düşüncelerini ortaya çıkarmak için problem çözme öğretimi ile ilgili görüş formu uygulanmıştır.

Araştırma, 2020-2021 eğitim-öğretim yılı bahar döneminde otuz bir 5.sınıf öğrencisine Niğde ilinde bir özel okulda uygulanmıştır. Ön testler uygulandıktan sonra on dört ders saati boyunca Polya'nın fikrine dayalı problem çözme öğretimi (PSI) uygulanmıştır. Bu araştırmada veriler ön test, son test ve kalıcılık testi olarak uygulanan ISPST ve WSPST isimli testlerden ayrı ayrı toplanmıştır.

Tek Faktörlü Tekrarlanan Ölçümler ANOVA tekniği, öğrencilerin hem ISPST hem de WSPST testleri için matematiksel problem çözme performans puanlarında 0.05 düzeyinde üç zaman diliminde istatistiksel olarak anlamlı değişimin gözlemlendiğini göstermiştir. Pearson Korelasyon analizi sonuçları, ISPST ve WSPST testlerine ait son test ve kalıcılık testlerindeki matematiksel problem çözme performansları arasında 0.05 düzeyinde güçlü bir pozitif korelasyon olduğunu göstermiştir. Ayrıca problem çözme öğretimi görüş formundan elde edilen sonuçlar, problem çözme öğretimin 5. sınıf öğrencileri üzerinde olumlu izlenimler bıraktığını ortaya koymuştur. Problem çözme öğretiminin matematiksel problem çözme performansı üzerindeki etkisini daha derinlemesine incelemek için ileride yapılacak diğer çalışmalarda nitel veya karma yöntemler kullanılabilir.

Anahtar Kelimeler: Problem Çözme, Problem Çözme Performansı, İyi Yapılandırılmış Problem, Yarı Yapılandırılmış Problem, Polya'nın Problem Çözme Basamakları

To Serpil Atasoy who is my idol

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LIST OF ABBREVIATIONS

ABBREVIATIONS

MoNE: Ministry of National Education

NCTM: National Council of Teachers of Mathematics

PSI: Problem Solving Instruction

ISPST: Ill-Structured Problem Solving Test

Pre-ISPST: Pretest of Ill-Structured Problem Solving Test

Post-ISPST: Posttest of Ill-Structured Problem Solving Test

Retention-ISPST: Retention Test of Ill-Structured Problem Solving Test

WSPST: Well-Structured Problem Solving Test

Pre-WSPST: Pretest of Well-Structured Problem Solving Test

Post-WSPST: Posttest of Well-Structured Problem Solving Test

Retention-WSPST: Retention Test of Well-Structured Problem Solving Test

CHAPTER 1

INTRODUCTION

Problem solving is the most used activity in daily life, and individuals generally overcome the situation independently. Turkish middle school curriculum underlines the importance of problem solving at all levels (Ministry of National Education [MoNE], 2018). In Turkey, a new curriculum was designed in 2013 according to the necessity of problem solving. In the mathematics curriculum in 2013, MoNE stated that one of the primary purposes of mathematics education is to develop students' problem solving skills. From this point of view, problem solving has an important place in the secondary school curriculum. For this reason, problem solving is considered a fundamental skill that is expected to be developed for every subject in the curriculum. In addition, it is suggested that problem solving should be regarded as a teaching approach or a learning tool from time to time. National Council of Teachers of Mathematics (NCTM) also underline the significance of enhancing students' problem solving skills as the first and foremost purpose of teaching mathematics (NCTM, 2000), and mathematics lesson should be designed by thinking about problem solving (NCTM, 1980). Although problem solving is vital for mathematics and daily life, many students have difficulties (e.g., TIMMS, 2000, PISA, 2003). According to 2003 PISA (The Programme for International Student Assessment) results, Turkey was 33rd out of the 41 countries participating in the implementation, and it was also 28th among the 30 OECD (Organization for Economic Cooperation and Development) countries (Yılmaz, 2011). In this sense, problem solving is an integral part of mathematics education worldwide.

Besides that, NCTM also states that problem posing is important for the mathematics lesson and suggests problem posing is used in mathematics lessons. According to Silver (1996), problem posing involves students generating new problems or reformulating the given problem. Lin and Leng (2007) stated that while the students pose a problem, they need to consider the context's nature and create possible solution paths. The problem posing process and consideration of multiple solution paths require excellent opportunities for encouraging divergent and flexible thinking. While problem solving has been taught based on Polya's problem solving stages, the problem posing requires students to generate new problems or reformulate the given problems (Mishra & Iyer, 2013).

Polya (1957) mentioned his problem solving stages to make the problem solving more understandable and meaningful. According to Polya (1957), problem solving consists of the following phases: understanding the problem, making plans, implementing the plan, and looking backward. In this study, ill-structured and well-structured problems were applied based on Polya's problem solving stages. Understanding the problem means seeing what is given and asked with the problem. Making plans means establishing a connection between asked and given data and creating meaningful paths to get the solution. In implementing stages, a plan is carried out to get an answer. In the last step, which looks backward, the solution is checked to control verification, and it is generally checked by conducting a new strategy to solve the problem.

Problem solving is the main part of the mathematics program worldwide. It is defined as that practical way of using mathematics to be aware of daily life and make valuable mathematics (Doorman, et al., 2007; Heppner & Petersen, 1982). According to NCTM (2000), problem solving is a complex process that requires knowledge from the previous to the new situation. In mathematics, Polya’s (1957) conception of mathematical problem solving involves a four-phase understanding of the problem, planning, implementing the plan, and looking back at the problem. According to Jonassen (2000) and Newell & Simon (1972), a general problem solver specifies two crucial sets of thinking processes related to the problem, (a)

the understanding problem and (b) making plans. Students' mathematical problem solving performance was measured by comparing scores over three time periods in this study. Along this line, two of these stages were a curial part of the current research to develop mathematical problem solving performance .

There are different definitions related to *problems* in the literature. According to Posamentier and Krulik (2009), the problem is that the situation exposes the learner to show determination and create a method that is not immediately known. Furthermore, the concept of *the problem* is defined by Orton and Wain (1994), problem states situation that excites problem solver's attention prompts them to research to solve the problem. For a mathematical situation to be a problem, it challenges problem solvers' curiosity and gives them independent thinking to search for the solution to the problem. Despite different *problem* descriptions in literature, the consensus is that the problem solver needs to have difficulty obtaining a solution (Kurbal, 2015). Some researcher categorizes the problem according to instructional models. Jonassen (1997) distinguished well-structured from ill-structured problems since each type of problem calls on different skills. Well-structured problems are the practice and practice questions found at the end of the chapters of the textbooks used in schools and universities. Such problems require applying a limited number of concepts, rules, and principles for a limited number of solutions. On the other hand, an ill-structured problem is one of the instructional models A given problem is not necessarily precisely defined or set up with a clearly defined set of data and background information in ill-structured. It cannot be resolved with a high degree of certainty which means there is no unique solution. Students learn to construct and defend reasonable solutions (Alexa DiBenedetta, 2014). In the current study, students started to solve the ill-structured problem and then continued with the well-structured version of the problem in each lesson during the problem solving instruction. In this study, Polya's problem solving stages were used during that process. Besides that, according to Saygılı (2017), if students encounter problems that lead them to think differently and are taught problem solving stages, their problem solving skills and performance might

be improved. Therefore, like the present, research is needed to enhance students' mathematical problem solving performance.

1.1 Purpose of the Study

The primary purpose of the current study was to investigate the effects of problem solving instruction on 5th grade students' mathematical problem solving performance across the three time periods. Also, the other aim of the study was to examine the relationship between 5th grade students' mathematical problem solving performance scores of Well-Structured Problem Solving Tests (WSPST) and Ill-Structured Problem Solving Tests (ISPST) after the problem solving instruction. In addition, students' thoughts about the contribution of ill-structured problems to their mathematical problem solving performance and problem solving instruction were shown in the current study. The main reason for using ill-structured problems was to direct students to think of multiple solution strategies on a problem. Students who face ill-structured problems (e.g., problems without numbers) need different ways to solve them since they will not see the numbers. For these types of problems, students should understand the problem first to develop strategies to solve the problem. In this sense, the current study aims to show the effects of Polya's problem solving by implementing ill-structured and well-structured problems.

1.2 Research Questions

The specific research questions addressed in this study are:

1. Is there a change in 5th grade students' mathematical problem solving performance scores over three time periods?

   Null Hypothesis 1 for ISPST: There is no statistically significant change in 5th grade students' mathematical problem solving performance scores across three time periods (pre-ISPST, post-ISPST, and retention-ISPST).

Null Hypothesis 1 for WSPST: There is no statistically significant change in 5th grade students' mathematical problem solving performance scores across three time periods (pre-WSPST, post-WSPST, and retention-WSPST).

2. Is there a relationship between the fifth-grade students' problem solving scores of ill-structured and well-structured problems solving tests at posttests and retention tests?

   Null Hypothesis 2: There is no relationship between the 5th grade students' mathematical problem solving performance scores of ill-structured and well-structured problems solving tests at posttests and retention tests.

1.3 Significance of the Study

Problem solving and problems that are forced problem solvers to think differently are significant in some perspectives.

According to Posamentier and Krulik (2009), problem solving has become the most critical content at all levels of teaching mathematics. According to NCTM (2000), the main aim of mathematics is to increase students' ability and attention to solving problems. Turkish middle school curriculums and NCTM underline the importance of problem solving at all levels. Along this line, many research studies have been conducted about the positive effects of problem solving on students' achievement in mathematics (Karaoğlan 2009; Ulu, Tertemiz & Peker 2016; Yıldız 2008). In addition to that, according to Posamentier and Krulik (2009), problem solving is the most important content at all levels of school mathematics.

Furthermore, there have been many studies about the importance of Polya's problem solving stages. Polya's steps positively affected students' problem solving achievement (Yıldız, 2008). Moreover, Karaoğlan (2009) designed an experimental study to examine the effect of problem solving on students' mathematics achievement. Results show that instruction in problem solving classes had a substantial advantage on students' problem-solving skills. There was a significant

positive correlation between students' problem solving and mathematics achievement.

Moreover, the first stage of Polya's problem solving is understanding the problem, which means understanding context, given, and asked in the problem. When the first stage is not achieved, students get insignificant results for using just numbers randomly given in problem (Mayer, 1985; Saygılı, 2017; Töre, 2007; Verschaffel and De Corte, 1993 Hegarty, Mayer & Mog, 1995).

In addition to that, many studies have shown that problem solving and problem posing are interdependent and support each other. It is frequently emphasized that problem posing is important in developing students' problem solving skills (Stoyanova, 1997; Silver, 1996; Cankoy & Darbaz, 2010). Participants were also exposed to problem posing for four hours in the present study. The purpose of applying problem posing was to increase students' understanding of ill-structured problems, and problem posing has used the problem which students had difficulty most.

As stated above, problem solving and Polya's problem solving stages is crucial for mathematics achievement; however, few studies have been conducted about using Polya's problem solving stages with ill-structured and well-structured problems. Hence, this research aims to fill the gap in this area by integrating Polya's four steps to the ill-structured and well-structured problems.

1.4 Definition of the Important Terms

Problem: Questions whose solution is not known beforehand and whose solution is not apparent are accepted as problems. It challenges problem solvers' curiosity and gives them independent thinking to search the getting solution (MoNE, 2013; Polya, 1957; Orton & Wain, 1994).

Ill-Structured Problem: Some elements of an ill-structured problem are either unknown or incompletely known. It forces students to express their ideas about the

problem to each other, create more than one plan, and defend their thoughts to solve by creating multiple perspectives (Jonassen, 2000). In the present study, ill-structured problems do not consist of numbers, which means the numbers are unknown elements of the problem.

Well-structured Problem: It requires the applications of finite numbers and principles, and it is found at the end of the textbooks being studied in schools and universities (Jonassen, 2000). It presents all the problem elements, and in the present study, the numbers are given in the problems.

Problem Solving: It refers to engaging in a task for which the solution plan is not apparent. Problem solving is an action that involves a wide range of mental processes and skills. Solving the problem is finding a result and finding a way out of the hassle (Polya, 1957; Töre, 2007). In the present study, problem solving refers to solving ill-structured and well-structured problems based on Polya's problem solving stages.

Mathematical problem solving performance: It refers to fifth-grade students' scores getting from ISPST and WSPST.

Problem Solving Phases of Polya: There are various problem solving model, and problem solving stages have cyclic nature (Polya,1957; Carlson and Bloom, 2005; Wilson et al.; Hanin and Van Nieuwenhoven, 2016). In this study, Polya's problem solving phases were used since it is the pattern familiar to fifth graders. Polya suggested the problem solving stages which consist of understanding problems, making plans, implementing the plan, and looking backward. In the present study, Polya's stages are also a cyclic model. Students first solved ill-structured problems, and they used the first two stages of Polya, which were understanding the problem and making plans. While devising plans, students repeatedly address the major parts of the problem from various angles. Also, when students passed the well-

structured problems, they started to the first step of Polya and continued with other stages. Moreover, while solving well-structured problems, students could also find new methods. In each step of Polya's problem solving, they checked the solution was correct or not.

Problem Posing: It was defined as the generation of new problem or reformulation of given problem (Duncer, 1945; Silver, 1996). The current study used reformulation of given problems. In other words, students posed well-structured problems using ill-structured problems.

1.5 Motivation for the Study

I have been working as a mathematics teacher in a private school for six years, and I observed that students focused on numbers directly while solving a problem and applied the four operations without thinking. In this sense, this research aims to improve students' reasoning and critical thinking skills to increase their mathematical problem solving performance. In addition, it is one of the aims of this research to break the prejudices against mathematics. The problems arise from the students' thinking of mathematics as only four operations without understanding what they read. In short, I aim to develop problem solving skills and make mathematics popular, but while doing this, I use twenty-first century skills to raise awareness in students about "thinking." Ill-structured and well-structured problems were used based on Polya's problem solving phases to serve this purpose. This research study is to investigate the change in 5^{th} grade students' mathematical problem solving performance scores over three time periods, the relationship between the posts and retentions scores of Ill-Structured Problem Solving Test (ISPST) and Well-Structured Problem Solving Test (WSPST).

CHAPTER 2

LITERATURE REVIEW

The primary purpose of the current study was to investigate the effects of problem solving instruction on 5th grade students' mathematical problem solving performance across the three time periods. For this reason, the problem, the studies about problem solving and Polya's problem solving stages, the effects of using Polya's problem solving stages in literature, and problem posing will be examined in this chapter.

2.1 Problem

When the problem is mentioned, mathematical problems based on four operations, mostly found at the end of the subject in mathematics textbooks, come to mind (Jonassen, 2000). However, the word problem has a broader meaning and is not necessarily related to mathematics. There are lots of problem descriptions in literature. Polya (1962) defined the problem as a situation where there is conscious action in orders to reach the solution with indirectly reachable aim. According to Schoenfeld (1983), if the problem solves directly (how hard it is), it is not a problem, it is just exercise. To use problem as word, it has to solve unfamiliar way, and direct to think differently. Also, according to Jonnasen (2000), problem is situation where an unknown entity. Therefore, consensus of the definition of problem is that there is an indirect way to solve the problem, and it is not easily found and explained.

When we define the situation as a problem, it should engage various knowledge and skills, and it should be indirect solution strategies. Besides that, the problem should be of interest to the student, and the students need to find a solution. When the literature is examined, there were variation of problems based on their

components or representations. According to Mayer and Wittrock (1996), problems were identified ill-defined, well-defined, and routine and nonroutine. Along with that, some researcher defined problems, which are pushed to students to think in details and different viewpoints, as a non-routine problem (Altun and Memnun, 2008; De Hoys, Gray & Simpson, 2004). The non-routine problems are unfamiliar problem types to exposed, and it is required extra cognitive effort (Mullis et al., 2003). Another description related to routine and nonroutine problems is that while computing skills and memorization are sufficient in solving routine problems, high-level scientific process skills such as organizing data, forming hypotheses, and interpreting are needed in solving nonroutine problems (Lee et al., 2014). Also, according to Polya (1962), to develop the problem solving skills students solve non-routine problems. Some researchers have done related to effects of non-routine problems on mathematics achievement in recent years (Altun ve Memnun, 2008; Kurbal, 2015; Ulu, Tertemiz & Peker, 2016; Saygılı, 2017).

Another variation of problems was related to their structuredness, and Jonassen (1997) distinguished the problems as well-structured and ill-structured. Well-structured problems are the practice and practice questions found at the end of the chapters of the textbooks used in schools and universities. Such problems require applying a limited number of concepts, rules, and principles for a limited number of solutions. Jonassen (2000) described the well-structured problems characteristics were as follows:

- All elements of the problem are presented.
- A limited number of rules and principle are applied in a predictable way during resolution.
- They have correct and predictable answers.

On the other hand, according to Jonassen (2000), the ill-structured problems had more solutions and vagueness about which concept rules are required for the answer. Also, Laxman (2013) stated that when students face ill-structured problems, they try to answer such a question “What do you mean?” Jonassen

(2000) and Laxman (2013) described the ill-structured problems characteristics were as follows:

- The elements of the problem are either unknown or known incompletely.
- It contains multiple inquiry paths.
- It forces students to express their ideas about the problem to each other, make judgments, and defend their decision to solve by creating multiple perspectives.

In the present study, ill-structured and well-structured problems were reviewed, and problems were created by the researcher considering the above characteristics related to well-structured and ill-structured problems. Ill-structured problems did not consist of numbers which were the unknown of the problems, and students first determined the information needed to solve the problem. Also, they explained their strategies and argued their plan with their friends to prove the correction of their thoughts. On the other hand, while solving well-structured problems, all elements were given, which means the numbers provided. Students applied plans created while solving ill-structured problems, and they reached the predictable solution.

After arguing problems, their definitions, and variation, we need to examine the problem solving and problem solving process. The solution of the encountered problems has special importance, and various definitions have also been put forward for problem solving. For example, Morgan (1999) defines problem solving as finding the best way to overcome the obstacle encountered. Problem-solving is perceived as an action that encompasses a broader mental process and skills. Solving the problem is finding a result and finding a way out of the hassle (Polya 1957). In the next part of the literature review, definitions, and studies of problem solving will be reviewed.

2.2 Problem Solving

Researchers' definitions of problem solving that student use informal strategies for solving their problems and it is related to how they make a relation between their mind and the problem (Gravemeijer, 1994; Johanning, 2004). In addition to that, NCTM (1980) and stated that problem solving is a process direct to students make a connection between prior and new knowledge, and the new mathematics teaching is developed to think this way (Lester and Kehle, 2003). Altun also has consistent opinion with the NCTM related to problem solving. He stated that problem solving is the conscious research of a scientific subject to reach a clearly designed but not immediately attainable goal. Problem-solving in mathematics eliminates the problem through mental activities using existing knowledge and processing skills.

The problem solving is heart of mathematics and mathematics lesson should be designed by thinking about problem solving (NCTM, 1980). In NCTM standards, the development of each student's problem solving ability is considered as the basis. Some of the NCTM's problem solving standards are as follows. Mathematics has many application areas, and problems are used to understand and communicate with other disciplines. Mathematical problem solving motivates students instinctively. Problem solving in school mathematics can arouse students' interests and desires. Problem-solving is fun, and students should not be deprived of this entertainment. Additionally, Polya (1957) explained problem solving as a main theme of doing mathematics like the NCTM. Also, Schoenfeld (1989) mentioned that problem solving activities change students' beliefs towards lesson positively.

As stated in the thoughts about the definition and requirements of problem solving, raising students as good problem solvers is not a new concept in mathematics education. Problem solving has emerged as the most significant concern at all levels in school mathematics over the years (Posamentier & Krulick, 2009). Good problem solvers need to flexibility during solving problem, so they tend to use

different content related process for the problem solving (Carlson and Bloom, 2005). In this regard, Polya (1957) stated that problem solving was the essential part of doing mathematics and suggested that problem solving consists of understanding the problem, making a plan, applying the plan, and controlling the solution. Polya explained problem solving "heuristics" process, and heuristics is how a problem solver attempts various approaches to find a problem, and heuristics consist of a systematic approach to the task. According to Wilson et al., some of the U.S textbooks took Polya's problem solving stages as a linear nature model. When the problem solving process was taken as linear, the solving problem was thought of as memorizing or practical procedure, and it led to focus on just getting an answer. Still, the linear model does not reflect the nature of Polya's stages since his purpose of teaching students to think. According to Polya, the primary aim of problem solving was teaching students to think, and the solving nonroutine problems' theme was also teaching how to think. If we start from this thought, problem solving stages have cyclic nature. According to Wilson et al., a student starts with a problem and engages in detail to understand it. The student attempts to devise a plan and may need to understand the problem better in this process. Or, when the student creates a plan, the student applies it out and be unable to do so. The next step may be creating a new strategy to solve the problem, going back to develop a new understanding of the problem. The student controls each step of the solution method.

Along this line, Carlson and Bloom (2005) studied on problem solving behaviors of 12 mathematicians by completing four problems. The researchers interviewed each participant one by one and asked them to verbalize their thought during solving the problem. After the close observations of these participants, the researchers noticed a cyclic pattern, and they classified four phases as orienting, planning, executing, and checking. The problem solving cycle of Carlson and Bloom was given in Figure 2.1. Also, they stated that experienced problem solvers cycled through plan-execute-check cycle multiple times to complete the problem. Therefore, Carlson and Bloom stated that problem solving has multidimensional framework.

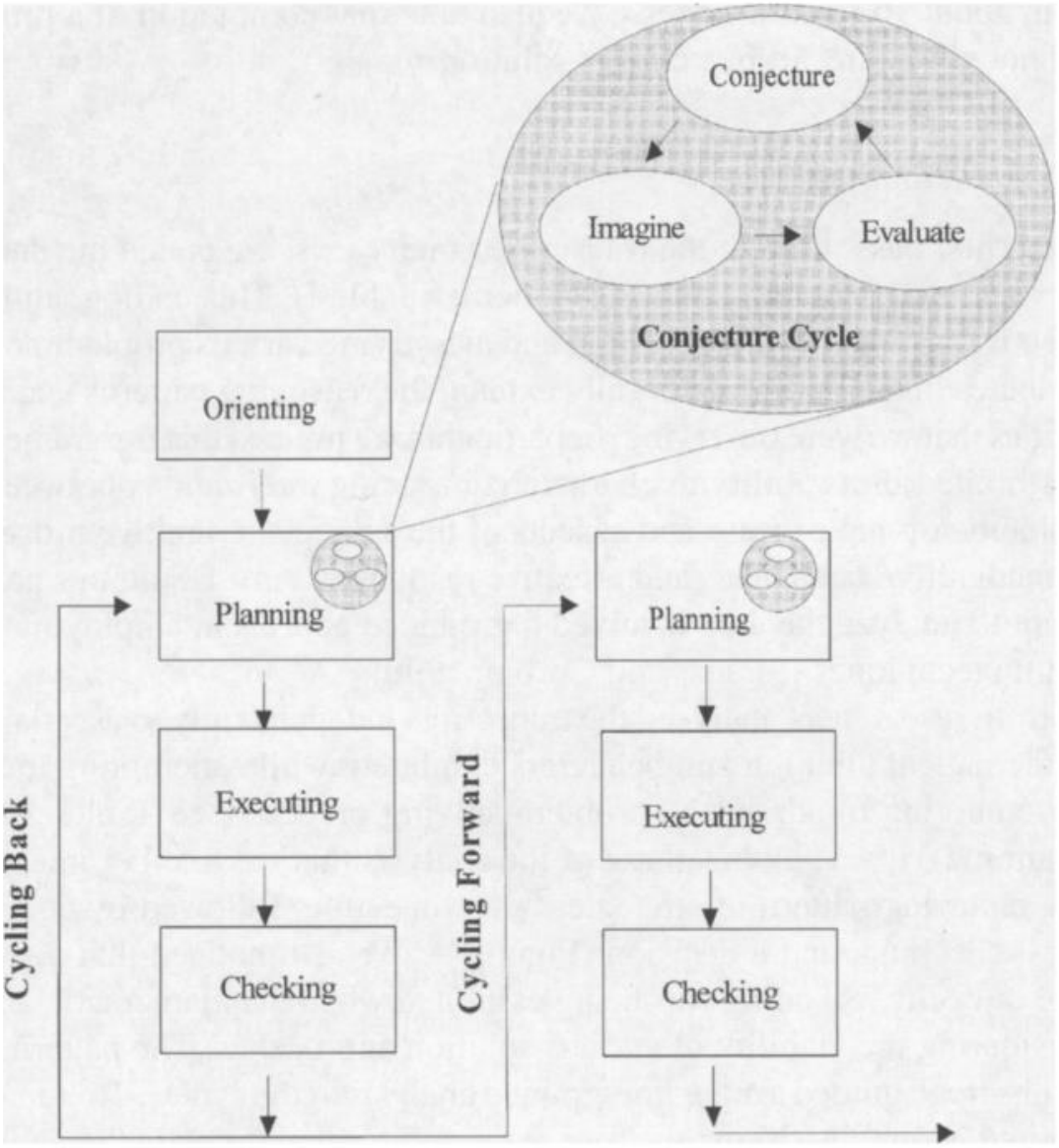


Figure 2.1 *The problem solving cycle of Carlson and Bloom*

According to Schoenfeld (1985), good problem solvers regularly observe and control their problem solving process. Along with this opinion, Schoenfeld developed a problem solving model consisting of five stages: reading, analysis, exploration, planning/implementation, and verification.

Arzt and Armour-Thomas (1992) also identified problem solving models by synthesizing Polya's and Schoenfeld' frameworks. Their problem solving phases

are reading, understanding, exploring, analyzing, planning, implementing, and verifying.

Hanin and Van Nieuwenhoven (2016) identified eight heuristic strategies to solve the problem from a different perspective. They stated that problem solving process must be cyclical and continued with back and forth between different stages. Figure 2.1 shows their problem solving process diagram.

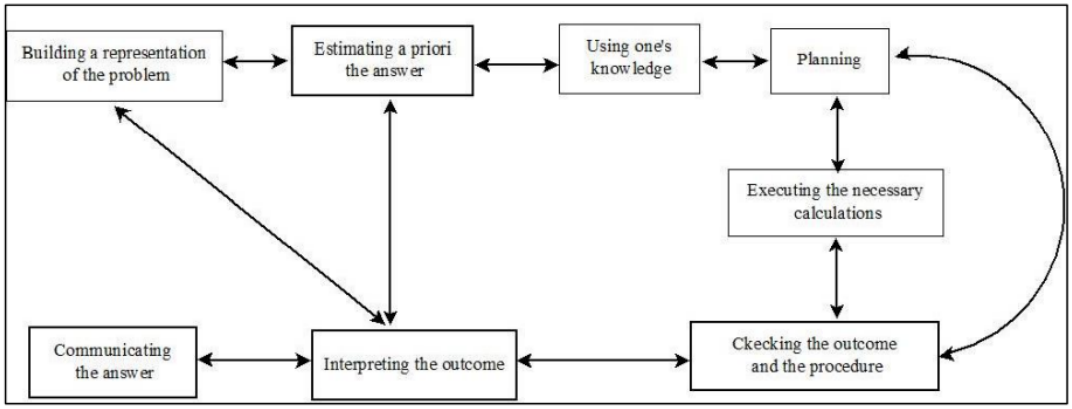


Figure 2.2 *Cyclical problem solving process of Hanin and Van Nieuwenhoven*

In summary, there are various opinion related to the problem solving but, in this light of above definitions of researchers, all consensuses are gathered under a single roof which is problem solving is the body of the mathematics teaching, and Polya's problem solving stages is the roof of this body. Within the framework of this research, George Polya's four-step model was taken as an example and the studies were shaped according to this model.

Polya's problem solving stages will be examined briefly in the following part of the literature review. The studies on the subject and the results of these studies will be given shortly.

2.3 Problem Solving Stages of Polya

In this study, treatment was conducted by using the Polya's problem solving steps which is accepted as strategic approach recommended for mathematics problem solving. Polya (1957) stated four steps to solve the problem in his famous book "How to solve it". In 1957, Polya suggested the problem solving strategy stages which consists of understanding problem, making plans, implementing the plan and looking backwards. The problem solving steps of Polya were summarized from book of "How to Solve it" (1957). The steps are given in Table 2.1.

Table 2.1 Problem Solving Steps of Polya

Polya's Problem Solving Stages	**Explanation of the Stages**
Understanding of the Problem	• Briefly explain the problem in your own words • Show the main parts of the problem, the unknown, the data, the condition. • Address the major parts of the problem repeatedly and from various angles.
Making a Plan	• Clarify what needs to be found, remember what information was given • Discover the relationship between given and asked • Control if you have solved any other similar problem like this before • Think of more than one plan for the solution • Take into consideration all essential notions involved in the problem

Table 2.1 (Cont'd)

Applying the Plan	• Carry out your plans of the solution • Check each step while applying the plan • Apply more than one plan for the solution to prove that it is correct
Looking Back	• Control each step of the solution strategy • Use a different plan for the solution or use the working backward strategy to control whether the answer correct or not

According to Polya, just solving the problem could not improve student's problem solving achievement, problem solvers follow a path to get success, and this path explained given above table. In some research, understanding the problem is the most and a major part of the problem solving steps since if this process is not occurred, students just do meaningless four operations with the numbers without any cognition process (Mayer, 1985; Polya, 1990).

According to result of research designing by Verschaffel and De Corte (1993), students, who showed high academic success in this study, used 67 percent of their time understanding the sentences of problems and meaning of the problems, used 33 percent of their time focusing and examining the numbers. Also, students, who showed low academic success in this study, used 43 percent of their time understanding the problem and the sentences, and used 57 percent of their time focusing just numbers on the problem.

In another study that supports this study, Töre (2007) studied on the level of knowing and applying the problem solving process of 6^{th} grade students. While searching for an answer to this problem, two problems were prepared, and the problems were applied to the selected students and Polya's problem solving four stages were used. The data obtained from the qualitative research and the some of the following results were obtained. Most of the mistakes made in the process of solving problems arise from the deficiencies in the step of reading and

understanding the problem. In the interviews with the students, “Which strategy did you use?” The students did not understand the question, and most of them asked the meaning of the word strategy. The emergence of such a result is due to the lack of problem solving teaching. Also, it has been observed that students have difficulties in solving non-routine problems, and it has been shown that the reason for this is that students try to solve the problem without using logical thinking and reasoning skills. Töre stated that to be a good problem solver, it is necessary to know these steps entirely and apply them correctly, to use a large part of the time to understand the problem and control what they do throughout the whole process.

Another research related to the importance of Polya’s first two stages, in the studies carried out by Hegarty, Mayer, and Mog (1995), student success in word-based and action-based solutions was examined. In word-based comprehension strategies, keywords such as "more, less, solid" are selected from the problem sentence, and the actions to be taken are decided by looking at the keywords (For example: addition if it says more, subtraction if it says less, multiplication if it says two times or three times etc.). While using action-based understanding, the plot of the problem is examined rather than the words, the relationship between the events is analyzed, and the whole problem text is focused. As a result of the study, it was seen that the students who used action-based understanding were more successful than the students who used word-based comprehension strategies.

Therefore, these research shows the importance of understanding the problems. In the light of these studies, using ill-structured and well-structured problems might be the big changes on student’s mathematical problem solving performance in positive way.

In addition to that, some researchers have done related to effects of non-routine problems on mathematics achievement in recent years (Altun and Memnun, 2008; Kurbal, 2015 Ulu, Tertemiz & Peker, 2016). Ulu, Tertemiz and Peker studied on effects of comprehension and problem solving strategy instruction on nonroutine problem solving success. In their study, students in the experimental group were given comprehension strategies and problem solving strategies training. The

problem solving process developed by Polya was used in the problem solving process. Reading comprehension strategies training was given to eliminate the mistakes in the first step of problem solving, and problem solving strategies training was provided to eliminate the errors in the second and third steps. In addition, control processes are included to activate the last stage of problem solving. At the end of the research, students in the experimental group have been successful in non-routine problem solving than the control group.

In the present study, ill-structured and well-structured problems were conducted by helping the Polya's problem solving stages, and there are so many studies about the effect of these stages to the students' mathematical problem solving performance or mathematics achievement. For example, Yıldız (2008) studied changes in 6th-grade students' mathematical problem solving ability after mathematics instruction based on Polya's problem solving stages. Also, he examined the students' attitudes towards mathematics and mathematical problem solving after the implementation. Polya's problem solving steps were used to solve a problem and used different solution plans. At the end of the study, findings showed a significant effect of instruction based on Polya's step on students' problem solving abilities positively. Also, students' attitudes to problem solving changed positively, and students' attitudes to mathematics were enhanced after the instruction.

In the current study, students solved given ill-structured and well-structured problems based on Polya's problem solving stages. On the other hand, in the last two worksheets, studies on problem posing are also included. The following section will briefly explain what is done in this study about problem posing and the place of problem posing in the literature.

2.4 Problem Posing

Some of the important reasons mathematical problem solving is at the center of curricula are that it positively affects learning in general, understanding mathematics, and mathematical thinking in particular (NCTM, 2000; Polya, 1973;

Schoenfeld, 1985). Also, NCTM stated that problem solving and problem posing are two critical concepts in teaching and learning mathematics.

In addition to that, many studies have shown that problem solving and problem posing are interdependent and support each other. It is frequently emphasized that problem posing is important in developing students' problem solving skills (Stoyanova, 1997; Silver, 1996; Cankoy & Darbaz, 2010). According to Silver (1994), problem posing may involve:

- Students posing problems under certain conditions
- Changing the already studied problems
- Generating new problems.

In this case, when students create a new problem based on their experienced, their purpose is not the problem's solution. This type of generation of the problem is called the formulation of the problem. After solving a particular problem, problem posing can also occur by generating alternative related problems, described as the reformulation of the problem. In connection with Silver's opinion, the present study used reformulation of given problems. In other words, students posed well-structured problems using ill-structured problems in the last two worksheets. While problem solving has been taught based on Polya's problem solving stages, the problem posing requires students to generate new problems or reformulate the given problems (Mishra & Iyer, 2013).

Many studies have shown that problem solving and problem posing are interdependent and support each other (Silver, 1996; Stoyanova, 1997; Cankoy & Darbaz, 2010). It is frequently emphasized that problem posing is of great importance in developing students' problem solving skills (NCTM, 2000). For example, Stoyanova applied problem posing to extend and explore students' problem solving. In this context, this study briefly focuses on problem posing-based problem solving teaching.

In Silver and their friend (1996) study, they studied posing mathematical problems with complex task settings before, during, and after attempting to solve a problem within a complex task setting. The participants were 53 middle school teachers and 28 preservice secondary school mathematics teachers, and they worked both individually and in pairs. In the study, participants generated a problem related to given task before solving, and then they posed problem associated with complex task after solving the problem. Responses were examined difference between problems posed before solving the problem and problems during and after solving. The findings showed that participants posed more problems before problem solving than during or after the problem solving. Also, findings showed that participants' experience with problem posing is not a barrier to using problem posing.

In addition to that, Cankoy and Darbaz (2010) compared problem posing-based problem solving instruction and traditional problem solving instruction in terms of success in understanding mathematics problems of students. The research is experimental, and the data of the study were obtained as a result of the pre-tests applied to the experimental and control groups. For ten weeks, problem posing-based problem solving teaching was applied to the experimental group, the post-tests applied to the experimental and control groups, and the reminder tests were used three months later to the experimental and control groups. In addition to the fact that the experimental group showed a much higher level of success than the control group in all dimensions of the problem understanding test (re-expressing the problem, visualizing, qualitative reasoning).

Despite all its benefits, it should not be forgotten that the main aim is to raise individuals who are good problem solvers, not very good problem solvers. Many educators show understanding of the problem at the beginning of the factors affecting problem solving (Polya, 1957; Mayer, 1982; Stoyanova, 1997; Cankoy & Darbaz, 2010). According the Cankoy and Darbaz, students who do not understand the problem cannot use an appropriate strategy to solve the problem, cannot solve the problem, explain what they are doing and why, or even try to solve the problem. Consistent with this thought, in the current study, students first tried to

solve the ill-structured problem, and then they continued with posing problems which mean they created well-structured problems.

2.5 Summary of the Literature Review

Problem definitions, problem solving definitions, and models in the titles given above, and the studies applied using Polya's problem solving strategies contributed to the formation of this research.

The conducted studies highlight the importance of Polya's problem solving stages. For example, studies of Verschaffel and De Corte, Töre and Hegarty, Mayer, and Mog showed the importance of problem solving stages of understanding the problem and making a plan. In the current study, the researcher began with solving ill-structured problems, which were used to show the importance of these stages.

The researcher also applied problem posing at the end of the PSI. The participants reformulated the ill-structured problems, and they formed the well-structured problems. After the posing the problem, they solved the problem based on Polya's problem solving phases. The studies revealed that problem posing as an integral approach to cultivate students' thinking in mathematics and enhance learner understanding.

The sum and the substance of mentioned above, when students face with the ill-structured problem, it helps students think differently, and give them a chance discovering new paths to solve the problem. Moreover, Polya's problem solving stages is also important to discover these new paths in easily and meaningly. This study also showed the effects of problem solving instruction on fifth grade students' mathematical problem solving performance.

CHAPTER 3

METHODOLOGY

The goal of the present study was to investigate of the effects of problem solving method on fifth grade students' mathematical problem solving performance. The research questions which were sought through this aim are given below:

1. Is there a change in 5th grade students' mathematical problem solving performance scores over three time periods?
2. Is there a relationship between the fifth-grade students' problem solving scores of ill-structured and well-structured problems solving tests at posttests and retention tests?

The aim of this chapter is to give information about the research design, participants, data collection instruments, reliability and validity of the study, data collection procedure, analyses of data, and the lastly the internal and external validity of the study.

3.1 Design of the Study

The purpose of this research study is to investigate the change in 5th grade students' mathematical problem solving performance scores over three time periods, the relationship between the posts and retentions scores of ISPST and WSPST and thoughts about problem solving instruction. The design of the study was one group pretest, posttest design which means this design do not have control group, and a single group is measured before and after exposure to some treatment (Fraenkel & Wallen, 2012). For seeking through first and second research questions, quantitative method was used. For the quantitative method, an experimental

research design was used but this study is also an example of "weak experimental design" which means that there is no control group to control the threats to internal validity (Fraenkel & Wallen, 2012). Problem solving instructions were given the fifth-grade students, and to observe changing of students' mathematical problem solving performance scores were examined using the students' pretests, posttests, and the retention tests. Two pre-tests (given in appendix A&B) were applied to participants at the beginning of the study, one of the pre-tests includes 6 ill-structured problems, and the other pre-test includes six well-structured problems. These pretests were applied to see the students' mathematical problem solving performance before the problem solving instruction. After the implementation of the pre-tests, problem solving instruction was given to the fifth-grade students. After the treatment, post-tests were applied to the students to see the students' mathematical problem solving performance after the instruction. Retention tests were also applied approximately two months after the post-tests to observe the effectiveness of problem solving instruction on students' mathematical problem solving performance. The design of the study was presented in Table 3.1.

Table 3.1 Research Design of the Study

Groups	Pretests	Treatment	Posttests	Retention Tests
Experimental Groups	ISPST WSPST	Problem Solving Instruction (PSI)	ISPST WSPST	ISPST WSPST

In table 3.1, "ISPST" represents ill-structured problem solving tests, and "WSPST" represents well-structured problem solving tests. In the pretests, posttests and the retention tests were identical problems.

Because of the pandemic situation, the instruction hours were not occupied for a certain period of the school. The problem-solving teaching hours were determined

according to the hours that the students were available. PSI was applied as two lesson hours between 19.00-20.30 in the evening. Because of the non-routine lesson hours, I am the researcher and the teacher at the same time in the study. According to Tabach (2006), being a teacher and researcher simultaneously is problematic because the teacher acts as the teacher and keeps the researcher's voice silent. But at the same time, Tabach (2006) defends that being a teacher and researcher simultaneously enhances the awareness in teaching and research.

3.2 Participants

Convenience sampling method was used in this study. Because of the pandemic situation, random sampling was difficult for the researcher so accessible school, that was a private school in Niğde, was chosen, and the researcher was working in this school. Convenience sampling is the most appropriate method during the difficult situation, but the sample cannot be used for representing the population (Fraenkel & Wallen, 2012). Two 5^{th} grade classes were chosen, and 31 fifth grade students from the two classes participated in the spring semester of 2020-2021 academic year. These two fifth grade classes were taught by the same mathematics teacher. One of the classes was 16 students: 8 girls and 8 boys. The other class was 15 students: 7 girls and 8 boys. Two of the classes were used for the experimental group, and there was no control group since the researcher did not reach the any school because of the pandemic situation. All lessons were given from the Google Meet, and one class was participated the lesson Monday and Wednesday, the other class was participated the lesson Tuesday and Thursday. Two classes took problem solving instruction on separate days since I did not want crowded courses. It was important for students to express their ideas clearly in problem solving teaching, so teaching was applied to two classes separately. 57 fifth grade students were participated to the pilot study of the tests, and 15 fifth grade students were also joined pilot study of Problem Solving Instruction.

3.2.1 The Role of the Researcher

I was working at the school which was chosen for the implementation. I was not the participants' teacher in the mathematics lessons at school. Still, I was the teacher in the PSI lessons since the application was made in the evening, and I have detailed information about how the application should be made. I created the activity sheets and instruments, and while writing the problems, I benefited from the fifth grade mathematics book of the Ministry of National Education Publications, published in 2013. PSI was applied to two classes separately during the fourteen class hours in the 2020-2021 spring semester. I started each lesson with ill-structured problems, in which students used the first two steps of problem solving. First, they discussed what they understood from the problem, and then they developed more than one strategy for each ill-structured problem to reach the asked in the problem. After that, I continued with well-structured version of the problem, and students used four stages of Polya. While students solved the ill-structured and well-structured problems, I was in the position of leading the question-answers and in-class discussions. Before the main implementation, I did the pilot study and took notes on the parts that the students had difficulties with and the important aspects of the study. I used these notes while making the actual application. By considering these notes, I made necessary changes in the activity sheets and flow of the PSI, and I explained all the implementation processes in detail following sections.

3.3 Context of the Study

The school was a private school in Niğde, and the school had a full-time education. In the school, students were coming from a high socioeconomic level, and the average size of the class was 20. Because of the pandemic situation, 2020-2021 education semesters were online, and students attended the lessons from their home. Most of the students had a computer or tablet, and they had an own room to

participate the online lessons as indicated by the school administration. Google Meet was used during the online lessons by the decision of the school administration. During the research, the instruction hours were not occupied for a certain period of the school, and the permission was taken for this class hours.

National Council of Teachers of Mathematics (NCTM) underlines the importance of the developing students 'problem solving skills as one of the main goals of teaching mathematics (NCTM, 2000) and asserts that mathematics lessons should be designed by thinking about problem solving (NCTM, 1980). Turkish Middle Grades Mathematics Curriculum also underlines the importance of problem solving at all levels (Ministry of National Education [MoNE], 2018). Improving the problem solving skill of the students were both the general aims of the curriculum and the fundamental abilities of the curriculum (MoNE, 2013, 2018). In 2013 Turkish Middle Grades Mathematics Curriculum, it was seen that problem solving should be used as instruction method. While the studies of the improvement of the problem solving skills, it consists following stages understanding problem, making a plan, implementing the plan, looking backwards in 2013 curriculum. Moreover, in 2013 Turkish Middle Grades Mathematics Curriculum, problem solving skills should be considered in the context of non-routine problems. Both 2013 and 2018 Turkish Middle Grades Mathematics Curriculums lay emphasizes on problem solving skills in mathematics education so data collection tools and problem solving method courses were designed by considering this perspective in current study.

3.4 Data Collection Method

The purpose of this research study was to investigate of the effects of problem solving method on 5th grade students' mathematical problem solving performance. Problem Solving Method Courses, and Ill-Structured Problem Solving Tests (ISPST), and Well-Structured Problem Solving Tests (WSPST) were constructed by the researcher. Pretests, posttests, and the retention tests were implemented to

the students, and the pretests, posttests and the retention tests were identical. In addition to that, problem solving courses were applied between pretests and posttests. Pilot study of the courses and the tests were conducted by the researcher that was also teacher of the courses in the fall semester of 2020-2021 academic years. After the pilot implementation, analyses were conducted with a mathematics teacher to examine the appropriateness of the problems regarding the mathematics curriculum, and the grade level of the students, and necessary adjustments were done also in light of the feedbacks from experts and students' solutions. Tests and problems used during the implication were revised after the pilot study, and these refine process will be explained clearly in the pilot study sections.

Data were collected in the spring semester of 2020-2021 academic years. Before the data collection, the necessary permissions were taken from Middle East Technical University Human Subjects Ethics Committee (see Appendix H) and the Ministry of National Education (see Appendix I). After the parents' approval forms were taken, the data collection process began. Beginning of the study, pretests of ISPST and WSPST were applied on different days to two classes, and then, treatment was occurred during the fourteen class hours to each class. At the end of the treatment, two post-tests which were same as the pretests were applied to each class to investigate effects of problem solving instruction on 5^{th} grade students' mathematical problem solving performance. Views about Problem Solving Method Questionnaire was also applied to the students to reveal of the students' opinion about problem solving instruction method courses. After approximately two months, retention tests were also applied to examine the effectiveness of problem solving instruction on students' mathematical problem solving performance. All the pretests, posttests and retention tests took around one class hour, and all these tests were administered to the students by the researcher. Also, students were informed about explaining their opinion about the courses clearly, and their answers were not shared anybody, and were not scored. In Table 3.2, the time interval and the content of the collection procedure were given below.

Table 3.2 The Sequence of the Data Collection Process

Date	Time Interval	Content
07.12.2020 - 29.12.2020	4 class hours for the pretests and posttests, 14 class hours for the PSI	Implementation of the pilot study
08.03.2021 09.03.2021	1 class hour to the 5/C 1 class hour to the 5/B	Implementation of the pretest of ISPST
10.03.2021 11.03.2021	1 class hour to the 5/C 1 class hour to the 5/B	Implementation of the pretest of WSPST
15.03.2021 16.03.2021	2 class hours to the 5/C 2 class hours to the 5/B	Implementation of the first work sheet of problem solving
17.03.2021 18.03.2021	2 class hours to the 5/C 2 class hours to the 5/B	Implementation of the second work sheet of problem solving
22.03.2021 23.03.2021	2 class hours to the 5/C 2 class hours to the 5/B	Implementation of the third work sheet of problem solving
24.03.2021 25.03.2021	2 class hours to the 5/C 2 class hours to the 5/B	Implementation of the fourth work sheet of problem solving
29.03.2021 30.03.2021	2 class hours to the 5/C 2 class hours to the 5/B	Implementation of the fifth work sheet of problem solving

Table 3.2 (Cont'd)

31.03.2021 01.04.2021	2 class hours to the 5/C 2 class hours to the 5/B	Implementation of the sixth work sheet of problem solving
05.04.2021 06.04.2021	2 class hours to the 5/C 2 class hours to the 5/B	Implementation of the seventh work sheet of problem solving
07.04.2021 08.04.2021	1 class hour to the 5/C 1 class hour to the 5/B	Implementation of the posttest of ISPST
12.04.2021 13.04.2021	1 class hour to the 5/C 1 class hour to the 5/B	Implementation of the posttest of WSPST
14.04.2021	1 class hours to the 5/B and 5/C	Implementation of Views about Problem Solving Method Questionnaire
01.06.2021	1 class hour to the 5/C 1 class hour to the 5/B	Implementation of the retention test of ISPST
02.06.2021	1 class hour to the 5/C 1 class hour to the 5/B	Implementation of the retention test of WSPST
03.06.2021	2 class hours to the 5/B and 5/C	Solving the problems of ISPST and WSPST

3.5 Data Collection Instruments

The aim of this research study was to investigate of the effects of problem solving method on 5th grade students' mathematical problem solving performance. An Ill-structured Problem Solving Test, A Well-structured Problem Solving Test, and Views about Problem Solving Method Questionnaire were used to gather data. ISPST and WSPST were used in pretest, posttest, and retention test. These tests and questionnaire form are presented below in detail.

3.5.1 Ill-Structured Problem Solving Test (ISPST)

Ill-structured Problem-Solving Test used in pretest, posttest, and retention test, and it was formed essay type of problems by the researcher (See Appendix A for Turkish version of the ISPST) . There were five ill-structured problems, and one of the problem had two items in the test. It was developed by the researcher with the help of 5th grade mathematics book which was used in mathematics lessons at public schools belong to Ministiry of National Education in 2013. In the Grades 5-8 National Mathematichs Curriculum (MoNE, 2013), it mentioned that non-routine problems are used in mathematics lessons, and problem solving process consists of these kinds of problems. During the process of creation of ISPTS, literature was examined, it was mentioned that students consider different kind of ideas and viewpoints in evaluating or solving ill-structured problems (Jonassen, 2000). Along this line, ISPST was implemented to force students to think in detail. When students face ill-structured problems, they will need to different ways to solve since they will not see the numbers. For these types of problems, students should understand the problem first to make a plan. In the ISPST, the 5th grade objectives about problem solving in the 2018 mathematics curriculum were the basis of ill-structured problems, which means these objectives were rewrite in detail considering the ill-structured problems. In Table 3.3, the fifth-grade objectives related to problem solving in the 2018 mathematics curriculum are given below.

Table 3.3 The Fifth Grade Objectives related to Problem Solving in the 2018 Mathematics Curriculum

Problem Solving
M.5.1.2.12. Students solve problems involving four operations. a) Students solve problems that require most three operations related with natural numbers. b) Students create own word problems.

ISPST consisted of 5 open-ended ill-structured problems; one of the problems had two items which means all with the items, there were 6 ill-structured problems (See Appendix A for Turkish version of the ill-structured problems in ISPST). When developing the ISPST, the researcher expanded on the 5th grade objectives related with problem solving in the 2018 mathematics curriculum. In Table 3.4, the new developed objectives of each ill-structured problem by the researcher were given below in detail.

Table 3.4 Objectives of Each Ill-Structured and Well-Structured Problem in ISPST and WSPST

Problem	**Objectives**
1	Students will be able to comprehend the difference between concept of "greater than" and "less than".
2	Students will be able to interpret a situation of "twice as many, three times as many as, four times as many as etc."
3	Students will be able to comprehend the relationship between part and whole.

Table 3.4 (Cont'd)

4	Students will be able to comprehend the difference between concept of "greater than" and "less than".
5	a) Students will be able to interpret a situation of "twice as many, three times as many as, four times as many as etc." b) Students will be able to comprehend the relationship between part and whole while solving the problem.

For the content validity, ISPST was evaluated by experts to control the appropriateness of the problems regarding the mathematics curriculum and the grade level of the students. In addition to that, it was piloted with 5th-grade students before the leading study research. After the pilot implementation, analyses were conducted with a mathematics teacher, and the researcher also made necessary adjustments in light of the feedback from experts and students. Pilot study of ISPST will be given in section 3.5.1.1 in detail.

3.5.1.1 Pilot Study of Ill-Structured Problem Solving Test

The pilot study of ISPST was conducted to 57 5^{th} grade students in Niğde during the fall semester of 2020-2021 academic year. The main purpose of the pilot study was to control the suitability of given time to the test, comprehensibility and difficulty of problems. There were six ill-structured problems under the five main ill-structured problems, and it took almost one class hour to the students to finish the test. Two problems have been revised in the test because of the comprehension issues during the pilot study of the test, and the reason for revising is explained in detail below. Focused holistic scoring point scale was used in evaluation process of ISPST, and this scoring scale was adapted from Charles et all (1987). Focused holistic scroring point scale was modifed by the researcher to see students' thinking process of problem solving steps (See Appendix D for Focused Holistic Scoring

Point Scale for ISPST). The range of points in this scale was 0-4, and the main point of using this scale is to see thinking process of the students. Also, the criteria for each assigning point were modified by the researcher examining students' solutions in the pilot study of ISPST. Thus, the maximum score which students can have in ISPST was 24 and the minimum score was 0. To increase the reliability, in the ISPST, all sample was coded by a mathematics teacher.

After the implementation of the pilot study, two problems were revised to make them more understandable. One of the problems that were revised was the third problem of the ISPST. In the third question of ISPST, while making a plan for solving the problem, students were required to use the image given in the problem. However, most of the students ignore the image, so they had difficulty in solving it. The correctness of this problem was few in the pilot study because of this reason. To overcome ignoring the image issues, the image was also expressed verbally in the problem. The old version and the new version of the third problem were given below, and the changes was expressed in detail.

A florist turns a certain number of flowers into bouquets, as in the adjacent picture. Given the number of flowers in the florist's hand and the bouquet price, which method or methods can we find out how much the florist earns from these bouquets? Explain your answer in detail.



Figure 3.1. *Old version of 3rd problem of ISPST*

In problem 3, students did not think of making flowers into bouquets that all included seven flowers, so most of them wrote that I multiply the numbers of the flowers and the bouquet price to find the florist's earning. They did not think that

flowers turn into a bouquet, or they did not know that a bouquet consists of seven flowers since some students set the number of flowers in the bouquet as a number they wanted. Therefore, the beginning expression of the problem was changed as "A florist turns a certain number of flowers into bouquets by using the number of flowers in the picture given on the side".

In the fifth problem of ISPST was revised since the problem consists unnecessery words, and students had difficulty to understand the problem. According to the pilot study analysis, students also gave few correct answers to this problem, so the researcher examined students' responses to clarify the problem. The old version of the problem was given below, and the revises of the problem were revealed in detail below.

A tennis player wants to buy the tennis racket and ball sets in the picture given on the right. The price of the racket in the picture is equal to the total cost of the ball sets.



a) Since the total price of the tennis racket and ball sets is known, by which method or methods can we find the cost of the racket and a ball set. Show your answer in detail.

b) The tennis player has a certain amount of money. The tennis player's money is just enough to buy the racket given in the picture and a few balls. How can we determine how many balls sets this person bought with the racket? Show your answer in detail.

Figure 3.2. *Old version of 5th problem of ISPST*

In problem 5th, some students divided the total price of the tennis racket and ball sets by 3 to find the cost of one set of balls or tennis racket. Namely, they thought that there were four products in the given picture, and all the products had the same

price. In addition, some students made a correct plan to find each product's price: a tennis racket and a set of balls, but then they calculated a sum of a tennis racket's price and a set of ball's price. Due to all these misunderstandings about the problem, the researcher changed the problem's expression to create a more apprehensible problem. Hence, the beginning expression of the problem was changed as "In a store, the total price of the ball sets given in the picture, and the cost of the tennis racket is equal". Additionally, item a of the problem was changed as "Since the total price of the ball sets and the tennis racket is known, what method or methods can we find out how many liras the racket and a ball set cost? Explain your plan in detail". In addition to all these changes, item b of the problem was also rewrite as "The tennis player has a certain amount of money. He can buy the racket given in the picture and a few sets of balls with all his money. Given that the amount of money the tennis player has is known, by what method or methods can we find out how many sets of balls he bought with the racket? Explain your plan in detail".

As a final point, after the pilot study of ISPST, two problems' expressions were changed to make them more comprehensible to students, and no revisions were made to the rest of the problems of ISPST.

For the content validity, experts were evaluated ISPST to control appropriateness of the problems regarding the mathematics curriculum and the grade level of the students. One of the experts from the university examined the ill-structured problems and their appropriateness of table of specification. Also, instructor from the universities and mathematics teacher examined the appropriateness of the ill-structured problems regarding the mathematics curriculum, and the grade level of the students. After the pilot study, the researcher and a mathematics teacher analyzed students' answers separately using the Focused Holistic Scoring for ISPST (See Appendix D) to check the usability and reliability of the tests. The inter-rater agreement process was applied for the pilot study of ISPST with the mathematics teacher with 13 years of experience, and there were 57 5th grade students in this pilot study. For ISPST, all students' solutions were coded by the

researcher and the mathematics teacher according to focused holistic scoring evaluations for ISPST. The agreement of the inter-rater tests reached above 98%.

3.5.2 Well-Structured Problem Solving Test (WSPST)

Well-structured Problem-Solving Test used in pretest, posttest, and retention test, and it was formed essay type of problems by the researcher (See Appendix B for Turkish version of the WSPST) . WSPST was applied three times at certain time intervals to see changes in response to problem solving intervention. There were five well-structured problems, and one of the problem had two items in the test. It was developed by the researcher with the help of 5th grade mathemathics book which was used in mathematics lessons at public schools belong to Ministiry of National Education in 2013. WSPST problems were prepared to be parallel to ISPST's problem. Both tests had the same objectives for all problems, but one's problems had consisted of numbers, and the other did not have a number.

WSPST consisted of 5 open-ended well-structured problems; one of the problems had two items which means all with the items, there were 6 well-structured problems (See Appendix B for Turkish version of the well-structured problems in WSPST). When developing the WSPST, the researcher expanded on the 5th grade objectives related with problem solving in the 2018 mathematics curriculum like as ISPST. ISPST and WSPST consisted of the similar problems, but WSPST had numbers in problems, so the objectives, which the researcher of WSPST developed, were also in above Table 3.5.

For the content validity, experts were evaluated WSPST to control appropriateness of the problems regarding the mathematics curriculum and the grade level of the students, and it was piloted with 5th grade students before the main study research. The process after the pilot study continued as in the ISPST. Necessary revisions were done with the help of pilot study and experts' feedbacks. Pilot study of WSPST will be given in section 3.5.2.1 in detail.

3.5.2.1 Pilot Study of Well-Structured Problem Solving Test

Prior to the main study, the WSPST was also piloted on 57 5th grade students in Niğde during the fall semester of 2020-2021 academic year. This study aimed to see the suitability of the given time, comprehensibility, and difficulty of problems. There were six well-structured problems under the five main well-structured problems, and one class hour was enough to finish the test. After the pilot study, three problems were removed, and one problem was added instead of them. The reason for eliminating problems was that making the WSPST parallel to ISPST, so one problem consisted of three sub-problems, and the two problems were similar to each other, and they served at cross objectives. Also, one problem have been revised in the test to get rid of misunderstanding, and the reason for revising is explained in detail below. Focused holistic scoring was used in the evalution of the students' responses, this scoring scale was adapted from Charles et all (1987). The researcher prepared different focused holistic scoring for each pretests that were ISPST and WSPST. Also, two focused holistic scorings modified from Charles et all (1987) to see students' problem solving steps (See Appendix E for Focused Holistic Scoring Point Scale for WSPST). The range of points in this scale was 0-4, and the criteria for each assigning point were modified by the researcher examining students' solutions in the pilot study of WSPST. Thus, the maximum score which students can have in WSPST was 32 and the minimum score was 0. WSPST was revised also to make the total points 24, since both ISPST and WSPST had same total points. To increase the reliability, in the WSPST, all sample was coded by a mathematics teacher.

After implementing the pilot study, the researcher made necessary changes to fit the problems to the objectives. Firstly, the first problem of the test consisted of three sub-problems in the pilot study, but three sub-problems were made into one problem to serve the objectives directly and make the WSPST parallel ISPST. The old version of the first problem were given below, and the changes was expressed in detail.

Dark and white chocolates are sold in a chocolate shop. Of the same size chocolates, the number of white chocolates sold in one day is 146 fewer than that of dark chocolates.



a) If the number of white chocolates is 362, how many dark and white chocolates are in the chocolate shop?

b) What can be done to equalize the number of dark and white chocolates in the shop? Please explain in detail.

c) 9 gram cocoa is used for each dark chocolate in the shop. Accordingly, how many grams of cocoa are needed for dark chocolate made in a day?

Figure 3.3. *Old version of 1st problem of WSPST*

First problem of WSPST had more than one objective, and students spent little too much time in the pilot study. Besides that, students, who did not find part a's answer or found the wrong solution for part a, did not solve, or give the wrong answer on the part of c of the problem. In part c of the problem, instead of finding the amount of cocoa needed for dark chocolate, some students found the amount of cocoa for the total number of chocolates, thus this part of the problem was removed from the test. In part b of the problem, students answered that "I sell 146 more dark chocolate, I sell 146 less white chocolate". Part b of the problem was unclear for the students, so the researcher eliminated this subproblem from the WSPST. To make the problem more comprehensible and the objective parallel to ISPST first problem was changed as "There is only dark and white chocolate in a chocolate shop. Of the chocolates of the same size, the number of white chocolates is 146 less than the number of dark chocolates. If the number of white chocolates is 362, how many dark and white chocolates are in total in the chocolate shop?"

One of the problems was removed from the WSPST since there was a similar problem in the test, which was the first problem. It served the same objectives in both problems. The removed problem was given below, and the reason for removing it was expressed in detail.

For the “Waste Battery Collection” campaign, an inter-class waste battery collection competition was organized. A total of 612 batteries of class 5-C and class 5-D were collected. The number of batteries collected by the 5-D class is 48 more than that of the 5-C class. According to this, how many batteries did the classes collect?



Figure 3.4. *The removed problem of WSPST*

This problem was eliminated from the test to make the total number of the problems and the objectives the same in both WSPST and ISPST. In this research, ISPST was applied first, and then WSPST was implemented, so when the students encountered the first pre-test, students understood the problem and did planning for the solutions. Since students will have faced with problems same objectives and similar kinds of problems in ISPST, it may be easier for them to make sense of and solve the problem in WSPST. Because of this reason, this problem was removed from the test after the pilot study.

Again, the same reason, which to make the total number of the problems and the objectives the same in both WSPST and ISPST, one problem was added to the WSPST after the pilot study. Before the main implementation of the study, mathematics teachers and experts evaluated whether the problems were appropriate for grade level and measurement. Also, the new problem was solved by the mathematics teacher and the students to test validity and to control the comprehensibility of the problem. The added problem was given below.

A stationery owner bought 960 balloons for 240 Turkish liras. He placed the balloons in packages with eight balloons in each package and sold all of the balloons. How much profit did the stationery owner make if he sold a pack of balloons for 4 liras?



Figure 3.5. *The added problem of WSPST*

The second problem of ISPST had the same objective to this problem, so to make parallel objectives and problems in both tests, the researcher created this problem for the WSPST.

In the fifth problem of WSPST, some wordings were added to make them more straightforward. The addition was explained below in detail.

In a store, the total price of the sleeping bags given in the picture is equal to the price of the tent.

a) If the total price of the tent and sleeping bags in the picture is 416 liras, how much is the price of a tent and a sleeping bag?

b) A customer who came to buy camping equipment received a tent and several sleeping bags in the picture. If the customer paid 312 liras for the tent and sleeping bags he bought, how many sleeping bags did he buy?



Figure 3.6. *The old version of 5th problem of WSPST*

In part of the fifth problem, most of the students found each price of a tent and sleeping bag, and then they summed up the price of tent and sleeping bag. The researcher added the words “price of tent and price of a sleeping bag” and gave spaces to write their answer, so students wrote each price to the assigned areas.
To end with, after the pilot study of WSPST, one problem consisted of three subproblems, two of them removed from the test. Also, one of the problems was eliminated, and the new problem was added to the test. In addition to some words added to another problem to make them more comprehensible to students, and no revisions were made to the rest of the problems of WSPST.

After the pilot study, the researcher analyzed students' answers using the Focused Holistic Scoring to check the usability and reliability of the tests used pre-tests, post-tests, and retention tests. Student comments about the problems during the administration process and analysis of the student answers in the pilot study provided significant insight into the data collection tool before the actual data collection process. Some corrections and adjustments were made under favor of those feedbacks and analyzes of the tests.

For the content validity, experts were evaluated WSPST to control appropriateness of the problems regarding the mathematics curriculum and the grade level of the students. One of the experts from the university examined the well-structured problems and their appropriateness of table of specification. Also, instructor from the universities and mathematics teacher examined the appropriateness of the well-structured problems regarding the mathematics curriculum, and the grade level of the students. After the pilot study, the researcher and a mathematics teacher analyzed students' answers separately using the Focused Holistic Scoring for WSPST (See Appendix E) to check the usability and reliability of the tests. The inter-rater agreement process was applied for the pilot study of WSPST with the mathematics teacher with 13 years of experience, and there were 57 5th grade students in this pilot study. For WSPST, all students’ solutions were coded by the

researcher and the mathematics teacher according to focused holistic scoring evaluations for WSPST. The agreement of the inter-rater tests reached above 95%.

3.5.3 Views about Problem Solving Method Questionnaire

Views about Problem Solving Method Questionnaire consisted of 9 open-ended questions and was created to examine whether using ill-structured problems positively contributes to solving well-structured problems (See Appendix C). Moreover, it was used to reveal students' opinions about instruction and problems but the answers from the students were not very detailed. Due to the insufficient data, no statistical study was made with the answers obtained from the students; they were only presented as application notes. In the questionnaire, the first two questions were about what comes to the student's mind when math lesson and problem is mentioned. At the beginning of the problem solving instruction courses, the researcher got students' opinions regarding the two questions were just mentioned since this questionnaire was applied at the end of the study. These two questions helped the researcher compare students' views about concepts of mathematics and problem at the beginning of the instruction to students' opinions at the end of the instruction. The other questions revolved around the contribution of solving ill-structured and well-structured to problem solving, students' comments and suggestions about problem solving instruction, and students' views about ill-structured problems since they encountered such problems for the first time in mathematics.

To ensure the content validity of the questionnaire, mathematics teachers gave feedback about the relevance of the questions to the problem solving instruction. The researcher did not apply a pilot study for this questionnaire. Still, the mathematics teacher and some students expressed their opinion about the comprehensibility and whether the number of questions will be too much for the students. Also, it was applied after the instruction and allowed 25 minutes to complete all the questions.

3.6 Treatment

3.6.1 Problem Solving Instruction (PSI)

The purpose of the present research study is to investigate of the effects of problem solving method on fifth grade students' mathematical problem solving performance and thoughts about problem solving instruction. Per this aim, a pilot study was applied before the main research, and then the researcher chose the experimental group with the help of the convenience sampling method. There was no control group for this research because of the pandemic situation and the insufficient number of students. Fall semester of the 2020-2021 academic year, a pilot intervention study was applied to 15 fifth grade students who participated from a private school in Niğde and took 14 class hours. The researcher created the problems with the help of 5th grade mathemathics book which was used in mathematics lessons at public schools belong to Ministiry of National Education in 2013 in the PSI, and mathematics teachers examined the problems for their curriculum relevance and intelligibility. Also, after the pilot intervention study, some problems were revised in the light of students' comments and taking into account the difficulties experienced by the students in the problems. The detail of the pilot study of PSI was explained 3.6.1.1 section.

In the PSI, there were seven worksheets, and the first worksheet consisted of one ill-structured and one well-structured problem. The other worksheets consisted of 2 ill-structured problems and two well-structured problems (See Appendix F for Turkish version of the problems in PSI). Each work sheet took 2 class hours, and students first solved ill-structured problems, and then they solved the same problem, but this time problem was well-structured. In the ill-structured problems, problems did not consist of numbers, and students just used two-step of Polya's problem solving steps, which were understanding the problem and making a plan. Students continued to solve well-structured problems, and they used their plans that were created to solve ill-structured and moved to apply their plans and check

the solution steps. According to Polya in his book How to Solve It (1957), the first step of problem solving was to understand the problem, and students must understand the verbal statement, so teachers control this situation. For this purpose, the researcher removed the numbers from the ill-structured problems, so students should understand the problem first from various sides to create a plan during the PSI. According to 2018 mathematics curriculum, students solve problems involving four operations, and students solve problems that require most three operations related with natural numbers. When creating problems in PSI, the researcher extended the fifth-grade objectives related to problem solving in the 2018 mathematics curriculum. The process of PSI was showed in table 3.5.

Table 3.5 The Process of Problem Solving Method

Objectives Students will be able to	**Time**	**Tools**	**Instructional Techniques**
*Comprehend the difference between concept of "greater than" and "less than". *Interpret concept of equality. *Comprehend relationship between part and whole.	2 Class Hours	Worksheet	Questioning Discussion
*Interpret a situation of "twice as many, three times as many as, four times as many as etc." *Comprehend the relationship between part and whole.	2 Class Hours	Worksheet	Questioning Discussion
*Comprehend the difference between concept of "greater than" and "less than". *Interpret a situation of "twice as many, three times as many as, four times as many as etc." * Comprehend relationship between part and whole.	2 Class Hours	Worksheet	Questioning Discussion

Table 3.5 (Cont'd)

*Interpret a situation of "twice as many, three times as many as, four times as many as etc." *Comprehend the relationship between part and whole.	**2 Class Hours**	**Worksheet**	**Questioning Discussion**
*Interpret a situation of "twice as many, three times as many as, four times as many as etc." *Evaluate what is equal to the concept of "more".	2 Class Hours	Worksheet	Questioning Discussion
*Comprehend the difference between concept of "greater than" and "less than". *Interpret a situation of "twice as many, three times as many as, four times as many as etc." *Evaluate what is equal to the concept of "less".	2 Class Hours	Worksheet	Questioning Discussion
*Interpret a situation of "twice as many, three times as many as, four times as many as etc." *Comprehend relationship between part and whole.	2 Class Hours	Worksheet	Questioning Discussion

For each worksheet, 2 class hours was allocated, and PSI was lasted 14 class hours. First worksheet consisted of one ill-structured problem and one well-structured problem. The other four worksheets consisted of 2 ill-structured problems and 2 well-structured problems. The last two activity sheets comprised two ill-structured problems and the two well-structured problems created by the students considering the ill-structured versions.

In the first lesson, which was lasted two class hours, the researcher was also the teacher of the lessons, asking the students' thoughts about the problem and how they solve the problem usually since students answered these kinds of questions in

the Problem-Solving Questionnaire. The purpose of the questions is to break down the students' prejudice related to the problem that consisted of numbers and four operations by solving ill-structured problems. Also, the students were asked what they did step by step while solving the problem. Students said that we first look what's given and asked, and then we solve the problems. After the discussion related to problem solving steps, Polya's four problem solving steps were introduced to students, and students were faced with the first ill-structured problem to use Polya's first two steps. First ill-structured problem was given below in figure 3.7 in the first worksheet, and then discussion process with the students will explain in detail.

There is a certain amount of goats and sheep on a farm. The number of sheep on the farm is more than the number of goats.

a) Given that the number of sheep and how much more sheep are than goats, which method or methods can we find out how many animals are in the farm in total?

b) Which method or methods can we use to equalize the number of goats and sheep on the farm?

c) The goats on the farm give the same amount of milk on average every day. Since the amount of milk obtained from a goat is known, which method or methods can we find the amount of milk obtained in a week?

Figure 3.7. *The ill-structured problem in 1st worksheet in PSI*

In the fifth grade, students meet this kind of problems in subject of problem, so the researcher began with this problem changing the ill-structured forms. Firstly, the teacher gave two minutes to read the problem and understand it. The teacher asked them what they understood from the beginning of the problem and the part a of the

problem and wanted them to explain their understanding. Students said that number of sheep was more than the number of goats, and we found the total number of animals on the farm. The teacher listened to all the students who wanted to speak and then asked them which methods they used to figure out the total number of animals on the farm. In this part, the students' first reaction was that put the numbers to the problem, and they tried to give the number to the problem for solving the problem. Also, they said that we did not know the numbers, so this problem could not solve. At this stage, the teacher turned to the beginning of the problem and asked students what were given at the problem, and students said about the number of sheep and how much more sheep are than goats. The teacher told students that they knew this information, found the number of goats, explained their methods. After the discussion about what they knew from the problem, and what they found in part a, the teacher chose students to explain their method, and they said that if we knew the number of sheep and how much more sheep are than the goats, we subtract the part of the sheep that is more than the goat from the number of sheep. Hence, we found the number of goats, and to find total number of animals, we added the number of sheep and goats. The teacher asked, *"Is there any other method we can use to find the total number of animals?"*. Thus, students thought about the problem deeply, and they tried to find different methods. One of the students said, *"If we think the number of sheep and goats are the same, we multiply the number of sheep by 2 to find the total number of animals. The number of sheep is much more than the goats, and how much more we know, so we subtract the excess part from the number just found as the total number of animals. After subtracting the excess part, we found the total number of animals on the farm."* Then the teacher asked the class to agree with their friend or not, and other students agreed with the friend. After this solution method, the teacher asked again whether there was another method, and students found a new way. A student said*, "This method resembles the second method in the way of proceeding from the whole, we first subtract the excess part from the number of sheep, and multiply this number by 2; thus, we consider the number of goats and*

sheep as equal and find the total number of animals. However, sheep are more than goats, so we add the excess part to the number just found, and we achieve a total number of actual animals on the farm." The teacher asked at every stage if there was a place in the solution methods that they did not understand. When there was something in the method that they did not understand, the teacher asked if any of the students would like to explain this method to their friend again, so students explained the methods each other step by step. After developing solving methods for part a of the problem, students began to understand what they did in an ill-structured problem, so the other two parts progressed quickly. Students started with understanding the problem and talked about what they knew from the problem and the methods to find the asked. At this stage, the students began competing with each other to develop more than one method. The researcher sent the first worksheet from WhatsApp to students before the lesson, so they wrote all these methods. In the ill-structured problem, students should talk about problem, and methods: thus, to create comfortable atmosphere and to get students to speak, the teacher followed such way. After the solving ill-structured problem, the teacher said that we used two steps, understanding the problem, and making a plan, from the Polya's problem solving steps for the ill-structured problem. After solving ill-structured problem, students passed the well-structured version of problem was given below in figure 3.8.

There is a certain amount of goats and sheep on a farm. The number of sheep on the farm is 124 more than the number of goats.

a) Since the number of sheep is 568, find the total number of animals on the farm.

b) Which method or methods can we use to equalize the number of goats and sheep on the farm?

c) Each of the goats on the farm gives an average of 3 liters of milk per day. Accordingly, find how many liters of milk are obtained from all the goats on the farm in a week.

Figure 3.8. *The well-structured problem in 1st worksheet in PSI*

The teacher gave students time to understand and make a plan, and students said that we applied the methods which found solving the ill-structured problem. Students applied the methods and explained their solution. After each methods explained and applied, she asked to students, *"How you control whether your solution correct or not?"* Students said, "*We used three methods solving this problem, and we got the same answer in every method."* The teacher said to students, *"If we control whether the answer is correct or not, we should find another method or use the working backward method. We used another method to control the solution to the problem. If we used the working backwards method for the first method, we could subtract the number of sheep from the total number of animals, finding the number of goats. To verify the number of sheep, we add the number of goats and part of sheep more than goats. If we achieve the number of sheep, which is 568, we solve the problem correctly; if not, we turn to the beginning of the problem and control our methods."* After this explanation, students control the first method using the working backward method. All these processes applied the methods found in an ill-structured problem and controlled

them whether it is correct or not, were continued of the solving part b and c. During the lesson, the teacher tried to get all the students to speak about the problem, since in this lesson students should talk, and explain their understanding from the problem and their method detailly. At the end of the first lesson, the teacher asked, *"What is your first observation for the ill-structured problem?*" Students said, *"At first we did not think there would be so many methods for a problem. After finding second method, we thought deeply about the problem to find another method."* One of the students said, *"For a moment, I thought I was in a method-finding contest."* In addition to that, students said, *"After facing ill-structured problem, we developed all methods for the problem, so solving well-structured version was so simple, since we understood the problem, and make plans in ill-structured version, so we just applied plan in this one."* After these explanations, the researcher said that we used four problem solving steps, created by Polya, solving the problem which were understanding the problem, making a plan, applying the plan and check the solution. In the first worksheet, there was one ill-structured and one well-structured problem. These problems' objective was that comprehend the difference between the concept of "greater than" and "less than" and comprehend the part and whole relationship.

In the second lesson, second worksheet was implemented in each class, and the researcher sent the worksheet from WhatsApp to students before the lesson The second worksheet's objectives were showed in Table 3.6, and it was lasted two class hours.

The teacher reminded Polya's problem solving four steps, and then gave time to student to think first ill-structured problem of the second worksheet was given below in figure 3.9.

In a library, the boxes are placed on the shelves as shown in the figure. Since each box contains the same number of magazines,

a) Since the total number of magazines in the boxes on the second shelf is known, which method or methods can we use to find the total number of magazines in the boxes on the first shelf?

b) By what method or methods can we find how much more magazines on the second shelf are than on the first shelf?

c) If another box of magazines is added to the first shelf, how many times the number of magazines on the second shelf will be the number of magazines on the first shelf? Would you please describe in detail the method or methods you use?

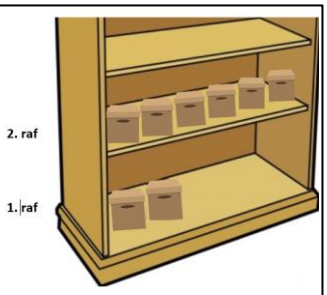


Figure 3.9. *The first ill-structured problem in 2nd worksheet in PSI*

The teacher asked the students what they understood from the problem to emphasize the beginning step of problem solving. In this lesson, students were more participants as they were familiar with ill-structured problems from the previous class. They explained their understandings from the problems, and specified the given and asked. Then, the teacher gave time to students to find solving methods for the problem. After the given time, students started to their methods; one of them said, *"I divided the total number of magazines in the boxes on the second shelf by 6, then multiplied the number just found by two."* At this point, the teacher asked the class, *"What did we find dividing the total number of magazines in the boxes on the second shelf by 6?" and "What did we found multiplying the number just found by 2?"* The purpose of these questions, to make students think about operations they apply in each step and what they find while solving problems. Students said, *"We found the number of magazines in one of the boxes dividing the total number of magazines in the boxes on the second shelf."*. The other student said, *"Multiplying the number just found by 6, we found*

the number of magazines on the shelf one." After the talking detailly of this method, one of the students said, *"I found a new method for this problem, there were six boxes on the second shelf, and there were two boxes on the first shelf which means that the number of magazines on the second shelf was three times the number of magazines on the first shelf. Hence, I divided the number of magazines on the second shelf by 3 to find the number of magazines on the first shelf."* In this solution method, students figured out the multiplying relation of each other, which was the purpose of adding the problem to the second worksheet. After the solving part a, teacher give time to think the class for part a and b. For every part of the problem, students began by explaining their understanding, and they discussed their methods with each other. The teacher enabled her to speak to all the students because she wanted to hear all students' opinions about the problem. Then, a well-structured version of the first problem in the second worksheet was solved with students (See Appendix F). They applied the methods was found to solve the ill-structured version, and then, since they used more than one method while solving the problem, they checked the solution of the problem. Also, one of the students controlled the solution by using the working backward method. The lesson continued with the second ill-structured problem in the second worksheet (see Appendix F). All the process was the same with the first ill-structured problem; the teacher just guided the students by asking questions to think deeply. First, students read the problem, discussed their understandings from the problem, then explained their methods. While students explained their plans, the teacher asked them what they found in each step or what their purpose was in each step. After solving ill-structured version of the problem, students passed the well-structured version of the problem, and implemented last two Polya's problem solving steps. At the end of the lesson, the researcher got their opinions about the lesson. Students generally said that today's lesson was easier since we learnt what to do. Also, after finding the methods in the ill-structured problems, solving the well-structured problems was so simple. At this stage, the researcher said that they could quickly solve well-

structured problems because you have previously completed the problem solving step in detail.

In the third lesson, third worksheet was applied in each class, and it was allocated two class hours. The researcher sent the worksheet from WhatsApp to students before the lesson, and objectives of third worksheet were showed in Table 3.6.

The first ill-structured problem served the same objective as the first worksheet (see Appendix F). The researcher asked this problem to evoke to students other two lessons. After completing solution of the ill-structured and the well-structured version of the problem by students, the lesson continued with the second ill-structured problem which was given below in Figure 3.10.

A customer wants to buy the tables and chairs given on the side. The price of the table in the figure is equal to the total price of the chairs.



a) Since the total price of the table and chairs is known, by which method or methods can we obtain how much the price of the table and one chair is in TL?

b) The customer has a certain amount of money. He can buy the table and a few chairs with all his money. Given that the amount of money the customer has is known, what method or methods can we find out how many chairs he bought along with the table?

Figure 3.10. *The second ill-structured problem in 3rd worksheet in PSI*

The teacher gave time to students for this problem. After waiting time, students explained their understandings of the problem. For the method of the problem, one students began with *"I divided total price of the table and chairs by seven, and I found each price of chair and table."* The teacher asked the class if they agree with their friend or not. Some students did not agree with their friend's method, and they

said, *"If we divided the total price of the table and the chairs by seven, we accepted price of one table is equal to price of one chair. However, this was not true."* The teacher also emphasized price of one table is equal to the total price of the six chairs. After the discussion, one student said, *"I divide the total price of the table and the chairs by 2, so I find price of one table or total price of the six chairs. Also, to find price of one chair, I divide total price of six chairs by 6, and I get the price of one chair."* All students agreed with the friend. The teacher asked the class whether another method or not. She guided them to think another way to the problem, and said *"If the price of table was equal to the price of six chairs, how many more chairs would that be instead of a table? How many chairs can we buy with the price of the table?"* Students answered that they could buy six chairs instead of a table. The teacher again asked that how many seats would be in total in this case. Then, they said that there were twelve chairs in total. At this point, one student said, *"In that case, I divided the total price of the table and the six chairs by 12, so I achieved the price of one chair. After that, I multiplied the price of one chair by 6 to find the price of one table."* In one class, one of the students developed this method before the teacher's guidance but in the other class, the teacher guided with the question to get the students this point. Beginning of the part b, teacher gave direction to students, *"Thinking that you have found the prices of the table and chair in part a of the problem, you need to solve this part."* One student said, *"I subtracted the price of one table from the amount of money of the customer, and I divided the number just found by the price of one chair"* The teacher wanted to students to tell what they found by subtracting and dividing, and another student explained the friend's findings. Then teacher asked, *"Are there different method for this problem? You think second method of the part a, establish a relationship with that method."* One of the students said, *"Customer buys just chairs with his money, so I divide the amount of money of customer by the price of one chair. Hence, I find the total number of chairs that he can buy with his money. We know that price of one table is equal to six chairs' price, so I subtract six from the total number of chairs. Therefore, I get the actual number of chairs that*

customers buy." At that point, teacher summarized two methods since the students had difficulty in the second method. After summarizing, the well-structured version of the problem was given as homework because of the time limitation.

In the fourth lesson, forth worksheet was applied in each class, and it was also allocated two class hours. Worksheet was sent from WhatsApp to students before the lesson, and objectives of it were showed in Table 3.6.

At the beginning of the lesson, the teacher summarized the problem given above in Figure 3.10, and she passed the well-structured version of the problem (see Appendix F). She said to the class, *"We examined the problem and their solving methods, and now we will follow the other two steps of problem solving, which apply the plan and check the solution."* After the explanation, students showed their works, and the class controlled the solution. The lesson continued with the other problems in the fourth worksheets. In this worksheet, problems were about comprehending the relationship between part and whole. First problem's ill-structured and well-structured versions were implemented to the students. First, students' understandings were discussed, and then students' solution methods were argued. After building consensus about solving strategies for the problem, they applied the ways and checked their solutions. The teacher remembered to class problem solving steps in each problem, and she asked them, *"What did you find doing that operation? Would you explain your findings in detail?"* After the solving first ill-structured and the well-structured version of the problem, the teacher continued with the other problem, and the same process was implemented in solving third and fourth problem of the 4^{th} worksheet. In the fourth worksheet, problems were familiar to the class, so they were faster and more comfortable solving problems, and all problems were completed in forth worksheet.

In the fifth lesson, fifth worksheet was applied in each class, and it was lasted two class hours. Worksheet was sent from WhatsApp to students before the lesson, and objectives of it were showed in Table 3.6.

In the first ill-structured problem given below in Figure 3.11, students discussed the understanding of the problem and argued the solution methods The purpose of that problem was to enable them to think creatively.

> In an animal shelter, only cats and dogs live. The number of cats and dogs is equal to each other.
>
> **a)** After a while, half of the cats in the shelter were adopted. An equal number of dogs were brought to the shelter due to bad weather conditions. Since the total number of cats and dogs at the beginning is known, how can we find the number of animals in the shelter in the final situation?
>
> **b)** Since the daily amount of food consumed by a cat and a dog is known, which method or methods can we find the total amount of food consumed in a day by the cats and dogs in the shelter at the beginning?
>
> **c)** How can we find the change between the total amount of food consumed in a day by the cats and dogs living in the shelter in the last case and the total amount of food consumed in the first case?

Figure 3.11. *The first ill-structured problem in 5^{th} worksheet in PSI*

After the discussing understandings from the problem, students explained their solution methods for this problem. In part a, one of the students said, *"I divided the total number of cats and dogs by two, and I found the number of cats and dogs separately. Then, I divided the number of cats by two because half of the cats were adopted. I multiplied the number of dogs by two since the number of dogs has doubled. Finally, I added the number of cats and dogs in the last state to find the total number of animals in the animal shelter."* Another student said, *"The number of dogs has doubled, so the number of the dogs was equal to the total number of the animal at the beginning in the last case. I found the at the end of the number of cats same as my friend. Then, I added the number of cats and dogs at the last case."* For part b, students answered the problem by multiplying each of the numbers of cats and dogs by the daily amount of food consumed by each one. In addition to that, some students said, *"We grouped the cats and dogs in pairs. Then, we added up the*

amounts of food consumed by a cat and a dog in a day. Finally, we multiplied the number just found by the number of groups to find the total amount food consumed by the cats and dogs in a day." In part c, some students found the amount of food consumed in the last case, and they examined the change between initial and final situation. However, some students just focused the changing, and they used findings from the part b. In the last case, the number of dogs has doubled, so the students thought that the amount of food consumed by dogs increased as the total amount of initial dogs' food consumed in a day. Also, the number of cats was halved, so the students thought that the amount of food consumed by cats decreased by half of the initial total amount of cats' food consumed in a day. The teacher listened to all the students who wanted to speak about their solving methods in the lesson. Also, students helped each other while explaining their methods. For instance, in second method of the part c, two students solved the problem with together, since they both found the same solution method. After the arguing solution methods of ill-structured problem, the teacher passed the well-structured version of the problem (see Appendix F). Students read the problem again, and then applied their solution methods. However, in the part b, one of the students found different method at that point. In part b, one cat consumed an average 60 grams of food in a day, and one dog consumed an average 240 grams of food in a day. Student said, *"The amount of food a dog consumes is four times the amount of food consumed by a cat. We think that there are cats in the shelter instead of dogs, and we know that there were 60 dogs in the animal shelter. The amount of food that 60 dogs eat is equal to the amount of food that 240 cats eat since the amount of food a dog consumes is four times the amount of food consumed by a cat. Hence, there are 300 cats which I found by adding the actual number of cats and the number when cats instead of dogs. Finally, I multiplied 60, which was the amount of food consumed by a cat in a day by 300, which was the total number of cats."* After this solution method, other students created a new plan impressed by his friend's solution, and he thought that all animals as dogs instead of cats. He solved the problem using this way. By applying these methods, they

have checked the solution of the problem. One of the classes was developed these methods, but the other one did not, thus the teacher indicated these methods to other class. During the solving problem, she observed that some students did not volunteer to solve the problem. She encouraged the students by giving them a voice in the implementation phase of the problem since the students felt comfortable at that stage.

After the completed four steps of problem solving for the first ill and well-structured problems, the teacher passed the second ill structured problem in given below Figure 3.12.

The total price of the shirts in the figure is equal to the price of the shoes. The price of the shoes is more than the price of the shirt. Since we know how much the shoes are more than the shirt, how can we determine how much the customer who buys a shoe and a shirt will pay?



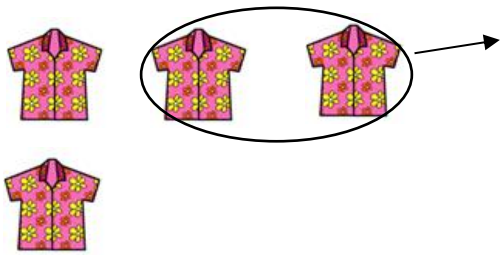
Figure 3.12. *The second ill-structured problem in 5th worksheet in PSI*

The teacher gave minutes to the class to understand the problem. After giving time, students discussed the understandings of the problem, and the teacher wrote the screen what they knew from the problem and what they needed to find since students had difficulty to comprehend the problem. Additionally, she wrote: (see figure 3.13)

The price of the shoes was equal to the total price of the shirts in the figure.

One shoe price equals to three shirts price

Let's think that we buy three shirts instead of shoes with the same money.



As shown in the figure, two more shirts are bought with the money given to the shoes. For this reason, the part of the shoe price more than the shirt is equal to the cost of two shirts.

Figure 3.13. *The teacher's summary for the second ill-structured problem in 5th worksheet in PSI*

After deducing the understanding of the problem, students made plans for the problem. They said that they divided the excess price of the shoes by 2, and they found the price of one shirt. Then, they found the cost of the shoes, and they added the price of the shoes and the price of the shirt since the customer bought one of each. In the final part of the method, some students said that the customer practically paid the price of four shirts since the cost of the shoes was equal to the three shirts prices. Thus, they multiplied the price of shirts by 4 to find out the amount the customer paid. At the end of the lesson, the teacher summurized the methods of the second ill-sturctured problem. Because of the time limitations, she gave well-strucured version of the problem as homework.

In the sixth lesson, sixth worksheet was applied in each class, and the researcher sent the worksheet from WhatsApp to students before the lesson. The sixth

worksheet's objectives were showed in Table 3.6, and it was allocated two class hours.

The teacher began with the lesson summarizing the previous lesson by solving the well-structured problem given as homework. Students completed the four steps of problem solving for this problem. The teacher followed a flow as in other lessons. Students were familiar with problems and problem solving processes in the sixth worksheet the teacher's expectations. In this lesson, the only thing different was that students added the numbers to the second well-structured problem themselves, and then they applied the plans with their well-structured problem. The purpose of this work was that students had difficulty solving this kind of problem, so they could think of the problem in detail while applying the plan. All students wanted to speak, explained their problem, and solved their problem. At that point, the teacher wanted all students to control the solution, whether correct or not. She wanted to write students their own ill-structured and well-structured problems as homework.

In the last lesson, seventh worksheet was implemented in each class, and the researcher sent the worksheet from WhatsApp to students before the lesson. The last worksheet's objectives were showed in Table 3.6, and it was lasted two class hours.

The teacher started the lesson by listening to students creating their own problems. Before the lesson, some students sent their problem to the researcher, and the teacher showed the problem to the class. The students explained their problem and solved Polya's four problem solving steps in the lesson. One of the problems came from students was given below in Figure 3.14.

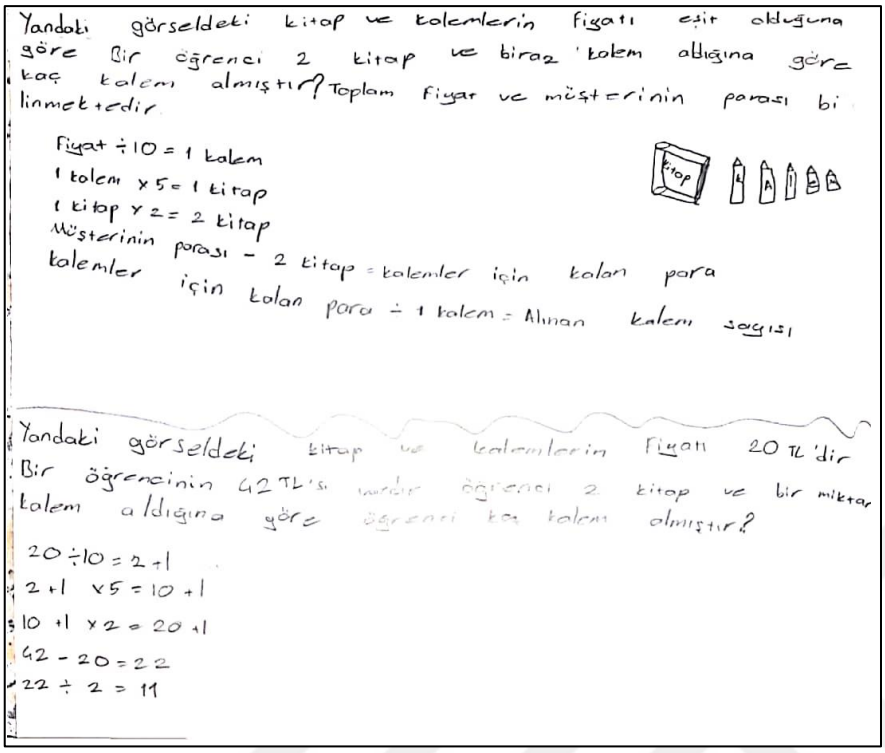


Figure 3.14. *The student's problems as homework*

After the students' presentation of their own problems, the teacher continued with the last worksheet. The first problem was familiar with the first ill-structured problem of the first worksheet but this one forced the students. Students began with the problem by discussing the understandings from the problem, and teacher guided the students to understand the problem. The teacher gave the students 10-15 minutes to think about the problem, and she wanted to students to create own well-structured version of the problem. After the developing it, she asked them to apply the methods they found on a well-structured problem and check the correctness of the answer. After the waiting time, students shared their well-structured problems and their methods and then solved the problems. After each student shared the problem and solved it, the teacher asked the class to control whether the solution was correct or not. If the student's answer was wrong after the check, the teacher asked the students where the wrong way was followed in the solution. The lesson

continued with the second ill and well-structured problems in the last worksheet. The students solved the similar kind of problem in the second ill-structured problem in 3rd worksheet. The flow was the same as in that lesson, and students solved these ill and well-structured problems faster. The teacher summarized Polya's problem solving stages again at the end of the lesson, and I thanked the students for their participation and their efforts and patience.

3.6.2 Pilot Study of Problem Solving Instruction

Before the main study, the fall semester of the 2020-2021 academic year, a pilot intervention study was applied to 15 fifth grade students who participated from a private school in Niğde. Pilot study of PSI took 14 class hours, and each lesson lasted two class hours. All lessons were given from the Google Meet, and the lessons held twice a week. Six worksheets were prepared by the researcher with the help of of 5th grade mathemathics book which was used in mathematics lessons at public schools belong to Ministiry of National Education in 2013. The pilot study aimed to see where students would have difficulty in ill-structured problems that students will encounter for the first time. Additionally, it aimed to decrease unexpected cases during the implementation of the initial study.

The teacher implemented the process of solving problems as in the main study, but she took notes on the problems that the students had difficulty with and the parts that took longer to revise before the initial research.

The teacher started the first lesson asking students opinions about problem and the way they follow about solving problems. Then, she explained Polya's problem solving four stages to students. She sent the first worksheet to the student, but first activity sheet consisted two ill-structured and two well-structured problems. When the first ill-structured and well-structured problems were finished, there was no time left to solve other problems. Students faced an ill-structured problem for the first time, so the teacher spent too much time on this problem. Additionally,

students' first reaction to the ill-structured problem was putting them numbers and solving the problem using them. The teacher spent more time at that point, and she directed the students' attention to Polya's two steps of problem solving: understanding the problem and making plans. She just wanted students to talk about understandings from the problem and explained givens and asked from the problem. She also enabled students to discuss the methods of solving the problem without using numbers. Consequently, the researcher removed the second ill-structured problem and well-structured problem from the first worksheet because of the time limitation. These problems were added to the second worksheet for the main study.

In the second lesson, the teacher began with the rest of the problems from the previous class. Students solved these problems, and the first ill-structured and well-structured problems of the second worksheet. The last ill-structured and the well structured problems were not solved because of the time limitation. Hence, these problems removed the second worksheet, and they added to the third worksheet for the main study.

The third lesson started with the problems which left from the previous lesson, and the ill-structured version of the problem was given above in Figure 3.10. After the arguing students understandigs from the problem, some students divided the total of the price of the table and the chairs by 7, since there were seven products in the figure. The teacher guided students asking such as, *"What did you find doing that? Would you please explain your method?"* Then, she asked students whether they agreed with the friend's method or not. After the discussion, the students found a new method to solve the problem. Also, the teacher encouraged students to create different ways to solve problem. In the well-structured version of the problem, she emphasized checking the solution step. She remembered the ways of controlling the solution methods, which found another method or working backward. She observed the students' difficulty during solving problems, and she took notes to help the students during the main study. The lesson continued with the first ill-structured problem in the third worksheet. The students solved this problem faster

since the problem was familiar to the student from the first worksheet. They also finished the well-structured version of the problem and checked their solution. The researcher transfered the second ill-structured problem and well-structured problem to the fourth worksheet for the main study.

The fourth lesson begin with the problems which left from the previous lesson (see the problem in the fourth worksheet in Appendix F). The teacher gave minutes to students to first step of the solving problem. For part a of the problem, some students said, *"We divided the total number of shots in tennis tournament by three since the tennis tournament occupied three periods, which were quarterfinal, semifinal, and final."* The teacher asked the class whether they agreed with their students or not. Other students did not agree with their friends, and they came up with an explanation like that *"In the tournament, each player shot same number in each play, so we divided the total number of shots by fourteen to find the number of one's shots."* After the discussing this method, the well-structured version of the problem was done. Then, teacher summarized the solving methods of the problem, and she passed the other ill-structured problem (see the second ill-structured problem of the fourth worksheet in Appendix F). The students solved this problem faster since they got used to this kind of the problem. The researcher transfered the second ill-structured problem and well-structured problem to the fifth worksheet for the main study.

In the fifth and sixth lessons, the flow was the same as other lessons, but the students had difficulty with the problem given above in Figure 3.12. Therefore, the teacher made an explanation and drew understandings to the screen in detail for the problem. The researcher created a new problem and added the sixth worksheet for the main study. The new problem is given in below in Figure 3.15.

The total price of the pencils in the figure is equal to the price of the pencil case. The price of a pen is less than the price of a pencil case. Since we know how much less is the price of a pen than the pencil case, how can we determine how much the customer who buys a pencil and a pencil case will pay?



Figure 3.15. *The new problem in 6th worksheet*

Also, the researcher solved the new problem at the last lesson in the pilot study. In addition to that, one problem was eliminated from the worksheets since students said that it was so easy, and they solved the problem much faster than the other problems. The problem's objective was that interpreting a situation of "twice as many, three times as many as, four times as many as etc." The Turkish version of the removed problem is given below in Figure 3.16.

Yandaki şekilde Turgut ve Tomris'in elinde pul koleksiyonları vardır. Zarfların içindeki pul sayıları eşittir.

a) Turgut ve Tomris'in sahip oldukları toplam pul sayısı bilindiğine göre, her birinin sahip olduğu pulların sayısını hangi yöntem veya yöntemlerle bulabiliriz?

b) Turgut ve Tomris eşit sayıda pula sahip olmak isterlerse, kimin kime kaç tane pul vereceğini ve son durumda her birine ait kaç tane pul olacağını hangi yöntem veya yöntemlerle bulabiliriz?



Figure 3.16. *The removed problem from the worksheet*

The researcher created a new problem instead of removing one, and the objective of the problem was similar to the first problem in the first worksheet. However, she extent the first problem to enable the students thinking deeply about the problem. She prepared a new worksheet which was the seventh worksheet for the main study since, in the pilot study, she transferred the second ill-structured problem and the well-structured version of it at the first worksheet to the following worksheet. Therefore, one ill and well-structured problem automatically transferred the following worksheets, and the researcher prepared the seventh worksheet. All worksheets consisted of two ill-structured and well-structured problems except the first worksheet, so the researcher developed a problem for the last worksheet. The mathematics teacher examined new problems for suitability to the grade level and comprehensibleness for the students before applying them. Turkish version of the new problem is given in below in Figure 3.17.

Aren'in kırmızı, mavi ve sarı renkte belirli bir miktar legosu vardır. Aren'in mavi legoları kırmızı legolarından bir miktar fazladır, ayrıca sarı legoları da kırmızı legolarından bir miktar fazladır. Aren'in toplam lego sayısı, mavilerin kırmızılardan ne kadar fazla olduğu ve sarıların kırmızılardan ne kadar fazla olduğu bilindiğine göre, Aren'in her renkten kaç tane legosu olduğunu hangi yöntem veya yöntemlerle bulabiliriz? Cevabınızı detaylı bir şekilde açıklayınız.

Figure 3.17. *The new problem in 7th worksheet*

At the end of the last lesson in pilot study, the researcher applied this problem, and students had difficulty related with creating methods. She helped the class to develop method for the problem. For example, she drew to the screen the students' understandings from the problem to clarify the given and asked in the problem. Also, she wanted them to create well-structured version of this problem to be the part of the problem solving process.

To brief, students had difficulty in ill-structured problem at the beginning of the pilot study. The seventh worksheet was prepared for the main study because of transferring some problems to other worksheets and added new problem. The course of the pilot study was the same as the main study. The researcher observed the problems and steps that students had difficulty with and took notes about these situations to overcome them in main study.

3.7 Data Analysis

In this research, quantitative research methodology was used, and a quantitative data analysis technique was utilized to answer the first research question. Repeated one-way ANOVA was conducted to see the change in 5^{th} grade students' mathematical problem solving performance since there were treatment and pretests, posttests, and retention tests. All statistical analyses were carried out by using the SPSS program. The first research question was investigated by comparing the pretests and posttests and retention tests. All students' solutions were evaluated using the focused holistic scoring developed from Charles et al. (1987) in the ISPST (See Appendix D for Focused Holistic Scoring Point Scale for ISPST). The range of points on this scale was 0-4, and the main point of using this scale is to see the students' thinking process.

Additionally, the focused holistic scale was used by assessing students' solutions in WSPST. The scale was also modified from Charles et al. (1987) (See Appendix F for Focused Holistic Scoring Point Scale for WSPST). The scale's range of WSPST was 0-4.

For the second research question, analysis of Pearson Product-Moment Coefficient of Correlation was utilized to examine the relationship between posts and retentions of ISPST and WSPST.

Views about Problem Solving Method Questionnaire was examined to reveal students' opinions about problem solving instruction courses and the ill-structured problems for the last research question.

3.8 Validity and Reliability

Validity means the appropriate, correct, meaningful, and valuable inferences of any measurement (Fraenkel & Wallen, 2012). Moreover, according to Fraenkel and Wallen, content-related evidence of validity means opinions related to the content and structure of the instrument gathered from the specialists. ISPST, WSPST, and the problems in PSI were controlled by the mathematics education researchers to provide validity of content-related evidence of mathematics teachers, Turkish teachers, and my supervisor. Mathematics education researchers and mathematics teachers examined the appropriateness of the instruments format, mathematics curriculum, and level of the difficulties of the problem for the 5th grade students. Also, adequate representation of the content domain, which is the problem solving covered by the variable, was measured by mathematics education researchers and mathematics teachers. Furthermore, the Turkish teacher examined the problems for the wording, miswriting, and misleading reading comprehension. The researcher prepared problems for the ISPST, WSPST, and PSI, with the help of the 5th grade mathematics book, which was used in mathematics lessons at public schools belonging to the Ministry of National Education in 2013.

Reliability means the stability and the consistency of the results provided by an instrument (Frankel et al., 2012). Reliability and validity were carried out by the researcher for the data tools of PSI. The details are given in this section.

3.8.1 Internal Validity

The term *interval validity* is referring to observe any relationship two or more variables should be unintended (Fraenkel & Wallen, 2012). Because of the weak experimental study of this research as indicated above, there were internal validity threats occur. Also, there were pandemic situation at 2020-2021 academic year, 5^{th} grade students did not go to the schools. Therefore, some internal validity threats

were subject characteristics, subject attitudes, researcher bias, mortality, and testing, and there could be the threats for this research.

Subject characteristics threat refers to individuals in the sample differ from each other in unintended ways. There were two class for the experimental group, and the researcher implemented the PSI to each class separately. If the intervention was made by collecting two classes one lesson, students could not share their opinions about problem comfortably, and the researcher would not get all students wanted to speak in each lesson. In this study, the data collected from fifth grade students who are at the same age and the same private school so prerequisite knowledge, and mathematical experiences will be assumed same level. Also, two classes had the same mathematics teacher in school. Hence, threat of subjects' characteristics was controlled, and reduced.

In addition to subject characteristics, subject attitude might be internal validity threats. The lessons were made online platform in the evening, since the lessons days and hours were decided by considering the suitability of all students participating. Therefore, students might get bored and feel tired. For the reduce this threat minimum, maximum 4 problems, two ill-structured and two well-structured, were solved each lesson, and the researcher tried to listen all students' opinion about the problem and encouraged them to share their ideas.

Another threat to internal validity is the collector bias. The researcher was the teacher of the treatment at the same time, so researcher bias might be the internal validity threats. Same guidance and attitudes were provided in each class during the treatment to eliminate the threat. A mathematics teacher observed some lessons in each class and filled the observation checklist related with flow of the lessons. This classroom observation checklist modified from Serin (2009), and the checklist' questions were changed to suit problem solving steps and online education (see the Classroom Observation Checklist in Appendix G). Moreover, when grading the students' answers for the pretests, posttests and retention tests, the researcher worked with a mathematics teacher to eliminate the threat.

Additionally, mortality threat which means loss of the subject (e.g. drop out of the study, absent during the treatment) might be the internal threat for this study. To overcome this threat, the researcher wanted to students to participate the pretests, posttests, retention tests and intervention. Besides that, the lessons were completed after school hours, and students participated from their homes.

Lastly, testing might also threaten the research since the same instruments were applied three times to the students. There were four weeks between pretests and posttests, and there were two months between posttests and retention tests to minimize this threat. Besides, the researcher stated that tests' results would not be scored and shared with anyone.

3.8.2 External Validity

The term external validity refers to extending the result of the study generalizing from a sample to a population (Fraenkel & Wallen, 2012). The sample should represent the population to generalize the result of the study. Therefore, this condition might not be carried out for this study because the sampling method was convenience sampling. The data was collected from one private school's students, so ecological generalizability conditions might not be provided to generalize the study to a larger population for this study. Therefore, the results of this study can be generalized to a population that has similar settings.

3.8.3 Reliability

Reliability refers to the stability of scores or answers obtained by instruments (Fraenkel & Wallen, 2012). The inter-rater agreement process was used to control the data collection instrument's reliability in the pilot study. The inter-rater agreement process was applied for the pilot study of instruments with the mathematics teacher with 13 years of experience, and there were 57 5^{th} grade students in this pilot study. For ISPST and WSPST, all students' solutions were

coded by the researcher and the mathematics teacher according to focused holistic scoring evaluations for ISPST and WSPST separately. The agreement of the inter-rater tests reached above 98% and 95% respectively. A pilot study of PSI was applied to 15 5^{th} grade students in a private school to check the reliability. Furthermore, to increase the reliability score, instruments were used three times as pretest, posttest, and retention test to the same groups after a specific time interval.

3.9 Assumptions and Limitations

3.9.1 Assumptions

The researcher assumed that standard conditions were provided for the participants to implement the data collecting tools in this study. Furthermore, in the data collection instruments, it was assumed that all participants reflected their thoughts, and they were not impressed by anybody.

3.9.2 Limitations

In a recent study, a non-sampling method was applied. The school was not chosen randomly; the researcher was working there. Because of the pandemic situation, the 5th grade students took online education in the 2020-2021 academic year. That is, the researcher reached only had access to students in her school. Therefore, a convenience sampling method was used, which created a limitation to generalizing the results.

Moreover, there was no control group to compare the experimental group due to insufficient participants. To minimize the effect of this limitation, ISPST and WSPST were implemented there times as pretests, posttests, and retention tests.

As a limitation, the lessons were conducted online from Google Meet due to the pandemic situation. A few of the students did not want to open their cameras, and

the teacher warned these students to listen and participate in the lessons. The teacher asked questions during PSI to make sure they attended the class. In future research, this study could be constructed again in face-to-face education to see the effects on 5^{th} grade students' mathematical problem solving performance.

3.10 Ethics

The necessary permissions were taken from the Human Research Ethics Committee and MoNE (given in appendix H&I). Furthermore, the researcher sent a parental approval form containing information about the study to the parents to inform them about the research and get permission. The students' permissions were also taken orally.

After collecting data, participants' personal information has been kept confidential. During the evaluating process, participants' names coded by using numbers, and the interrater coder did not have any information related to the participants.

CHAPTER 4

RESULTS

This chapter presents the descriptive and inferential statistical analysis and findings in detail to respond to the research questions below.

1. Is there a change in 5^{th} grade students' mathematical problem solving performance scores over three time periods?
2. Is there a relationship between the fifth-grade students' problem solving scores of ill-structured and well-structured problems solving tests at posttests and retention tests?

The first research question was examined for both the results of ISPST and WSPST separately. The second research question was observed for posts and retentions of ISPST and WSPST by conducting Pearson Product-Moment Coefficient of Correlation. The flow of this chapter continued with descriptive and inferential statistics results of ISPST, descriptive and inferential statistics results of WSPST, analysis of correlation between posts and retentions ISPST and WSPST scores.

4.1 Descriptive Statistics Results of the ISPST

The ISPST included six ill-structured problems under the five main ill-structured problems. This test was applied to students as pretest, posttest, and retention test. The focused holistic scoring point scale was conducted to see students' thinking process of problem solving steps. The range of points on this scale was 0-4, and the main point of using this scale is to see the students' thinking process. Also, the criteria for each assigning point were modified by the researcher examining students' solutions in the pilot study of ISPST. Thus, the maximum score students can have in ISPST was 24, and the minimum score was 0. The descriptive statistics

of the tests are given in Table 4.1. The following table summarizes the descriptive statistics obtained from the pre, post, and retention tests.

Table 4.1 Descriptive Statistics Results of the Pre-ISPST, the Post-ISPST and the Retention ISPST

	Pre-ISPST	Post-ISPST	Retention-ISPST
N	31	31	31
Mean	8.52	15.29	15.84
Std. Deviation	7.42	7.51	7.73
Minimum	0	2	2
Maximum	24	24	24

As seen in the table, the mean score of the pretest was 8.52 (SD= 7.42), the mean score of the posttest was 15.29 (SD= 7.51), and the mean score of the retention test was 15.84 (SD= 7.73). Considering these results, it can be said that the mean score of the tests increase gradually.

Answers of students and percentages of grades for each problem in pre-, post- and retention ISPST are given below in detail.

Problem 1

The first problem's objectives were about comprehending the difference between the concept of "greater than" and "less than." The problem is given in Figure 4.1.

In the first problem, students' solutions were graded as 0, 1, 2, 3, and 4. The percentages of these scores are given in Table 4.2.

In a school, as part of Forest Week, middle school students decided to organize a tree planting event to re-green a forest area damaged by fire. Students will plant a certain number of Karaçam and Toros Sediri for this activity. The number of Toros Sediri to be planted is less than Karaçam.

Since we know the number of Toros Sediri to be used and how much less Toros Sediri is than Karaçam, how can we find the total number of trees to be used in the event?



Figure 4.1. *1st problem in ISPST*

Table 4.2 Percentages of scores for the 1st Problem of the ISPST

	Pre-ISPST	Post-ISPST	Retention-ISPST
0	45.2%	12.9%	12.9%
1	12.9%	3.2%	6.5%
2	6.5%	22.6%	16.1%
3	19.4%	6.5%	0%
4	16.1%	54.8%	64.5%

In the pretest, students have encountered this kind of problem for the first time in mathematics. Students generally gave numbers to the trees and found a total number of trees. Also, when they saw the word “less,” they thought that they would remove the lesser part of the Toros Sediri to find the number of Karaçam. Additionally, some of the students wrote that they would add lesser part to the Toros Sedir, but they did not report any reason to explain why they used this method and what they found doing addition. However, in posttest and retention test, most of the students explain their methods in detail so the pergentages of score

of 4 increased gradually. Table 4.3 presents examples from the students' solutions and scoring.

Table 4.3 Scoring of Students' Response for the 1st Problem

Scoring	Response
0	Karaçamdan Toros sedirini çıkarırım.
1	Kullanılacak toros sediri ağacından toros sediri ile karaçamın arasındaki fark çıkarılmalı.
2	Toros sediri ağacının saysından, toros sediri ile karaçamın farkını çıkararak karaçamı buluruz. Karaçamda bilinen Toros Sediri ağacı ile toplarız.
3	İlk olarak iki ağaç sayısı arasındaki sayıyla Toros Sedirindeki ağaç sayısını toplarım sonra oluşan sonuçla Toros sayısını toplarım.
4	toplam ağaç sayısını bulmak için, toros sedirini ve karaçamı eşit düşünüp toros sedirini 2 ile çarparım.Sonrasında toros sedirinin karaçamdan az olan kısmını toros sedirinin 2 katına ekler ve toplam dikilecek ağaç sayısını bulurum.2.yöntem: toros sediri ile toros sedirinin karaçamdan az olan kısmını toplarım ve dikilecek karaçam sayısını bulurum. Sonra karaçam ile toros sedirini toplayarak toplam dikilecek ağacı bulurum.

As seen in Table 4.3, when students got a score of 4, they explained their solution strategy correctly, and they used the appropriate plan in terms of the given in the problem. In addition to that, some of the students planned proper solution strategies, but they did not label or specify what they found. These kinds of responses were scored as 3.

Problem 2

The second problem's objectives were about interpreting a situation of "twice as many, three times as many as, four times as many as etc." The problem is given in Figure 4.2.

In the second problem, students' solutions were graded as 0, 1, 2, 3, and 4. The percentages of these scores are given in Table 4.4.

There are an equal number of magazines in the boxes on the shelves given in the picture. Since we know how much less the number of magazines on the first shelf is than the number of magazines on the second shelf, which method or methods can we find out how many magazines are on the shelves? Explain your plan in detail.

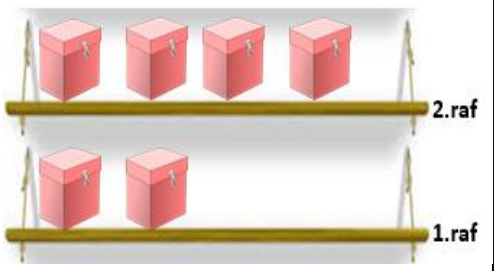


Figure 4.2. *2nd problem in ISPST*

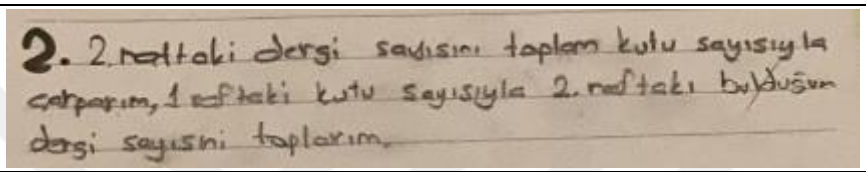
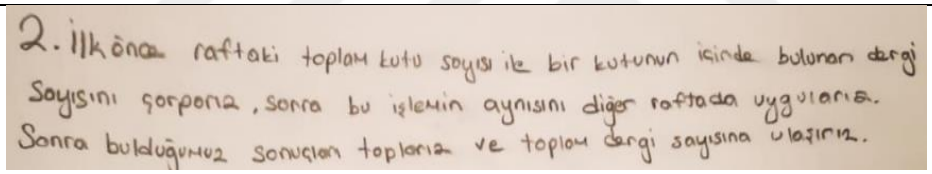
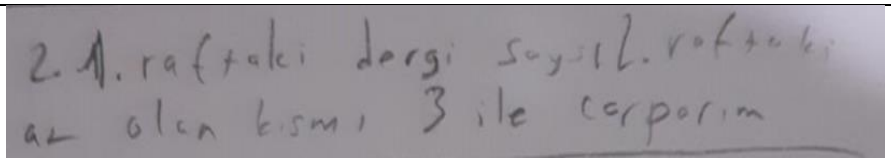
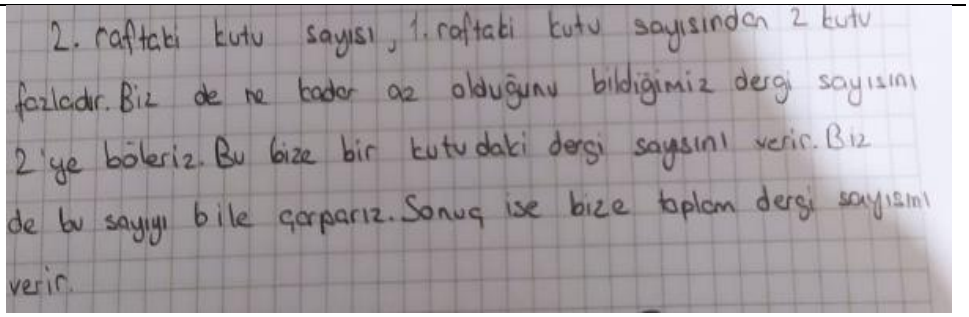
Table 4.4 Percentages of scores for the 2nd Problem of the ISPST

	Pre-ISPST	Post-ISPST	Retention-ISPST
0	38.7%	25.8%	16.1%
1	32.3%	6.5%	12.9%
2	9.7%	9.7%	12.9%
3	6.5%	0%	6.5%
4	12.9%	58.1%	51.6%

In the 2nd problem, some students wrote that they multiplied the nımber of boxes by the number of magazines in one box. Also, some students gave a number to the magazines in one box and calculated the total number of magazines on the shelves. It can be said that some of the students had difficulty understanding the problem; that is, they did not realize whats given and asked in the problem. When they saw the word "less" in the problem, they wanted to make addition or subtraction to

respond to the problem, ignoring what was described in the problem. From the pretest to posttest, the percentage of score four increased, but the percentage of score four decreased from posttest to retention test. Table 4.5 presents examples from the students' solutions and scoring.

Table 4.5 Scoring of Students' Response for the 2nd Problem

Scoring	Response
0	 2. 2. raftaki dergi sayısını toplam kutu sayısıyla çarparım, 1 raftaki kutu sayısıyla 2. raftaki bulduğum dergi sayısını toplarım.
1	1. raftaki dergi sayısı ile 1. raftaki dergi sayısının 2. raftaki dergi sayısı ile arasındaki sayı toplanır, çıkan sonuç ile 1. raftaki dergi sayısı toplanır.
2	 2. İlk önce raftaki toplam kutu sayısı ile bir kutunun içinde bulunan dergi sayısını çarparız, sonra bu işlemin aynısını diğer raftada uygularız. Sonra bulduğumuz sonuçları toplarız ve toplam dergi sayısına ulaşırız.
3	 2. 1. raftaki dergi sayısı 2. raftaki az olan kısmı 3 ile çarparım
4	 2. raftaki kutu sayısı, 1. raftaki kutu sayısından 2 kutu fazladır. Biz de ne kadar az olduğunu bildiğimiz dergi sayısını 2'ye böleriz. Bu bize bir kutudaki dergi sayısını verir. Biz de bu sayıyı bile çarparız. Sonuç ise bize toplam dergi sayısını verir.

As seen in Table 4.5, if there was work but no apparent understanding related to the problem, it was scored as 0. However, some students started with an inappropriate plan that reflected few understandings of the problem, and they got 1 point. For

example, in the second picture given in Table 4.5, students showed that the number of magazines on the second shelf is much more than on the first shelf, although they did not make a correct plan to find the number of one box. Furthermore, some students started with a partially correct plan based on the part of the problem being interpreted correctly, and this kind of solution was scored as 2, such as the third picture in Table 4.5. They did not explain their method of finding the number of magazines in one box, and it is understood from here that some of the students partially understood the problem. Additionally, in the fourth picture in Table 4.5, students applied an appropriate solution strategy but did not specify why they multiplied the lesser part by 3. It can be said that students understood that the lesser part was equal to the number of magazines on the first shelf, but they did not specify their method in detail. Moreover, when students got a score of 4, they gave proper plans and explained their plans in detail.

Problem 3

The third problem's objectives were about comprehending the relationship between part and whole. The problem is given in Figure 4.3.

In the third problem, students' solutions were graded as 0, 1, 2, 3, and 4. The percentages of these scores are given in Table 4.6.

A florist turns a certain amount of flowers into bouquets by using the number of flowers in the picture given on the side. Given the total number of flowers and the bouquet price, which method or methods can we find out how much the florist earns from these bouquets? Explain your plan in detail.



Figure 4.3. *3rd problem in ISPST*

Table 4.6 Percentages of scores for the 3rd Problem of the ISPST

	Pre-ISPST	Post-ISPST	Retention-ISPST
0	41.9%	16.1%	19.4%
1	12.9%	9.7%	12.9%
2	0%	16.1%	3.2%
3	19.4%	3.2%	6.5%
4	25.8%	54.8%	58.1%

In the third problem, some students had difficulty turning the flowers into bouquets by using the number of flowers given in the picture in Figure 4.3. It is understood that some students did not reach the relationship from whole to part. Because of this reason, they multiplied the bouquet price by the total number of flowers. Moreover, some students did not pay attention to the picture showing the number of flowers in the bouquet, and they gave a random number to the flowers in the bouquet. Still, the number of students getting 4 increased in post- and retention tests. Table 4.7 shows examples from the students' solutions and scoring.

Table 4.7 Scoring of Students' Response for the 3rd Problem

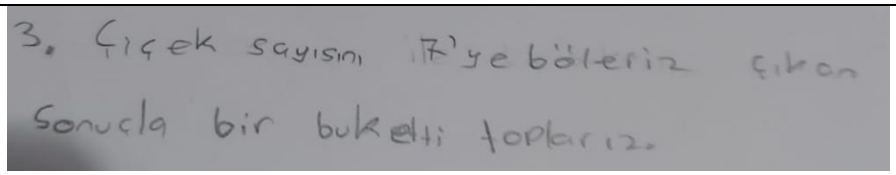
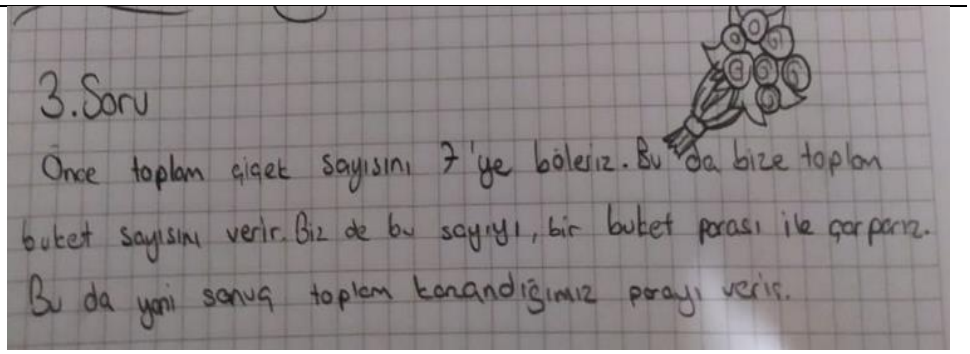
Scoring	Response
0	Çiçekleri ve buketleri toplarız.
1	kaç lira olduğunu bildikten sonra bu buketlerle Tl'yi çarparız
2	
3	toplam çiçek sayısını 7ye böleriz ve çıkan sonucu bir buketin fiyatıyla çarparız ve sonucu buluruz

Table 4.7 (Cont'd)

4	

As seen in Table 4.7, some students got 0 points as in the first picture since they saw flowers and bouquets and made addition using them. They showed no clear understanding of the problem. In the second picture from Table 4.7, some students did not specify what price is known, how many bouquets are there, and how we find the number of bouquets. They just thought the last part of the problem that earning money. It is understood that these students reflect little understanding of the problem, and these kinds of solutions were scored as 1. Also, as seen in the third picture, some students began with a correct strategy, but they did not carry out far enough to get a solution. It also presents a partial understanding of the problem, and it was scored as 2. Furthermore, when students did not label or specify what they found, they got 3 points. For example, in the fourth picture, some students did not explain what they found dividing the total numbers of flowers by seven. Lastly, when students created a proper plan and presented it in detail, they got 4 points.

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Problem 4

The forth problem's objectives were about comprehending the difference between concept of "greater than" and "less than". The problem is given in Figure 4.4.

In the forth problem, students' solutions were graded as 0, 1, 2, 3, and 4. The percentages of these scores are given in Table 4.8.

Demir and Yusuf have cartoon magazine collections. Yusuf's magazine number is less than Demir's magazine number. Since it is known how many magazines the two friends have in total and how few magazines Yusuf had compared to Demir, how many magazines Demir and Yusuf have, by which method or methods can he find out? Explain your method in detail.

Figure 4.4. *4th problem in ISPST*

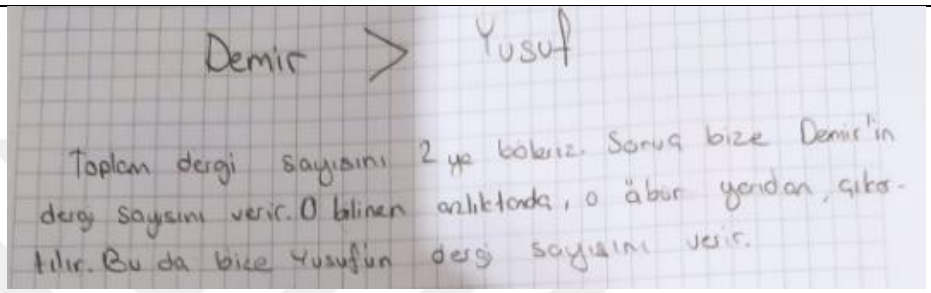
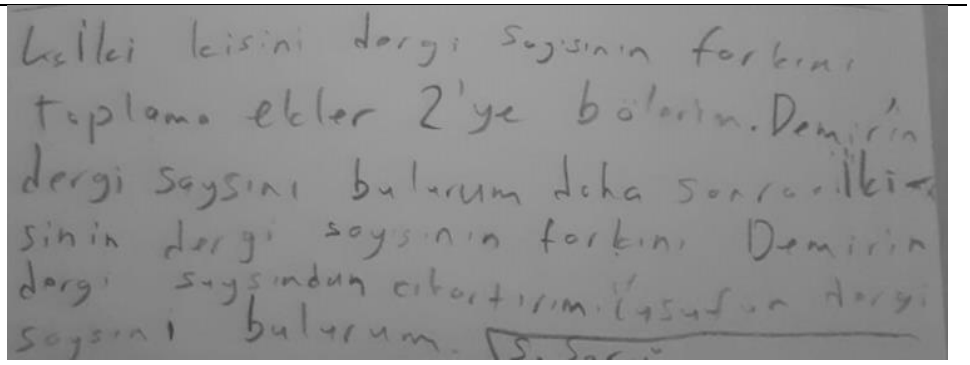
Table 4.8 Percentages of scores for the 4th Problem of the ISPST

	Pre-ISPST	Post-ISPST	Retention-ISPST
0	58.1%	22.6%	29.0%
1	9.7%	6.5%	3.2%
2	6.5%	25.8%	29.0%
3	9.7%	9.7%	12.9%
4	16.1%	35.5%	25.8%

As is seen from Table 4.8, most of the students had difficulty in forth problem. Most of the students misinterpreted the problem that Yusuf's magazine number is less than Demir's. They began with the plan thinking both Yusuf and Demir were equal magazines, so they wrote that we divided the total number of magazines by two. However, they added Yusuf's magazines' lesser part to half of the whole magazines and found the number of Demir's magazines. Also, they substracted the Yusuf's magazines' lesser part to half of the total magazines and found the number of Yusuf's magazines. Therefore, it is realized that students cannot imagine that they have doubled the difference between magazine numbers of Yusuf and Demir by planning in this way. From the pretest to posttest, the percentage of score four

increased, but the percentage of score four decreased from posttest to retention test. Table 4.9 presents examples from the students' solutions and scoring.

Table 4.9 Scoring of Students' Response for the 4th Problem

Scoring	Response
0	Yusuf'un dergi sayısı Demir'inkinden daha az olduğu için Yusuf'un 20 Demir'in ise 40 dergisi olur.
1	
2	Dergi sayısını ikiye böler pay ederim sonra Yusuf'un dergi sayısı ne kadar azsa onu çıkartıp Demir'e veririm ve olay çözülür.
3	İki arkadaşın toplam dergi sayısından aralarındaki dergi farkını çıkarırsak ikisininde eşit olabileceği dergi sayısını buluruz ve bu sayıyı 2 ye bölersek 1 kişide kaç tane dergi olduğunu buluruz.
4	

In the first picture in Table 4.9, some students gave a number to the unknown in the problem, but it was presented that the total number of magazines were known and lesser part of Yusuf's magazines compared to Demir. However, some students gave a number to magazines each of Yusuf and Demir. It was seen that no understanding

of the problem and these kinds of responses scored as 0. Additionally, In the second picture of Table 4.9, some students did not pay attention to keeping the total number of magazines fixed. They changed the whole number of magazines doing that plan given in the second picture, and they got 1 points. On the other hand, some students who got 2 point did not change the whole number of magazines, but they have doubled the difference between Yusuf and Demir's magazines number. Moreover, some students had planned correct solution strategy, but they ignored finding both Yusuf and Demir magazines condition. It reflects significant understanding of the problem, and it was scored as 3. Lastly, when students got 4, they had planned proper strategy and explained it in detail. It was scored as 4. From pretest to retention test, students made progress about concepts of "less than, greater than" and kept the whole fixed, but most students struggle with this problem, as seen in Table 4.8.

Problem 5

The fifth problem's objectives were about interpreting a situation of "twice as many, three times as many as, four times as many as, etc." and comprehending the relationship between part and whole while solving the problem. Fifth problem consisted of two problems. The problem is given in Figure 4.5.

In the fifth problem, students' solutions were graded as 0, 1, 2, 3, and 4 for each part a and b of the problem. The percentages of these scores are given in Table 4.10 and 4.11 for part a and b of the problem.

In a store, the total price of the ball sets given in the figure is equal to the price of the tennis racket.



a) Since the total price of the ball sets and the tennis racket is known, by what method or methods can we find how much the price of the racket and a ball set is in TL?

b) The tennis player has a certain amount of money. He can buy the racket, and several ball sets given in the picture, complete with his money. Given that the amount of money the tennis player has is known, by what method or methods can we find out how many sets of balls he bought with the racket? Explain your plan in detail.

Figure 4.5. *5th problem in ISPST*

Table 4.10 Percentages of scores for part a of the 5th Problem of the ISPST

	Pre-ISPST	Post-ISPST	Retention-ISPST
0	45.2%	16.1%	16.1%
1	6.5%	19.4%	12.9%
2	9.7%	12.9%	3.2%
3	9.7%	3.2%	9.7%
4	29.0%	48.4%	58.1%

Table 4.11 Percentages of scores for part b of the 5th Problem of the ISPST

	Pre-ISPST	Post-ISPST	Retention-ISPST
0	61.3%	32.3%	29.0%
1	3.2%	3.2%	0%
2	12.9%	12.9%	6.5.%
3	0%	0%	3.2%
4	22.6%	51.6%	61.3%

As seen in Tables 4.10 and 4.11, most of the students tried to make a plan for part a of the problem, but they left part b of the problem blank. In ISPST, students need to understand the problem and make a plan for the problems. Because of this reason, part a and part b of the problem were independent of each other; that is, as the students did not find any numbers, no answers affected each other in these parts of the fifth problem. Some students had difficulty with the concept of "equality"; they had trouble comprehending that the total price of the ball sets is equal to the cost of the tennis racket. They inferred that there were four products in the figure and all had the same price, and they divided the total price of the ball sets and the tennis racket by 4. When the percentages of results were compared, students made progress from the pretest to retention test, and the rate of making a correct plan for the problem has increased gradually. Tables 4.12 and 4.13 show examples from the students' solutions and scoring for the fifth problem.

Table 4.12 Scoring of Students' Response for part a of the 5th Problem

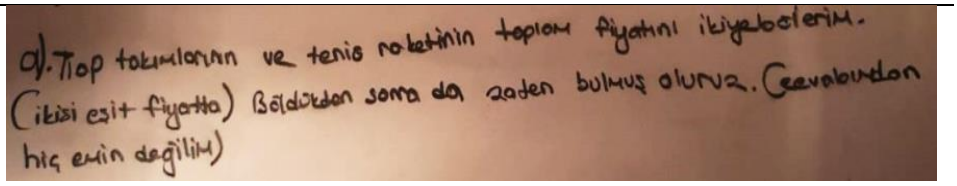
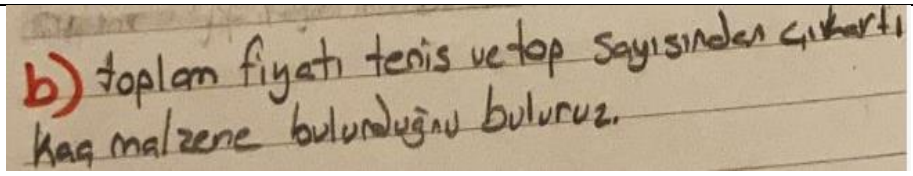
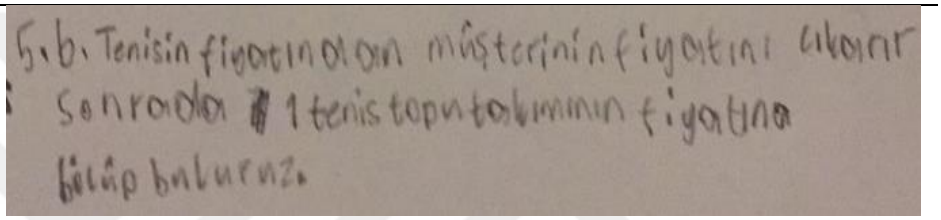
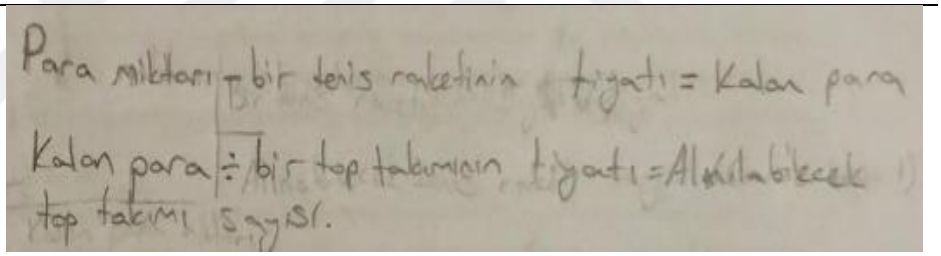
Scoring	Response
0	a) Raket ve topun fiyatlarını toplarız.
1	a)bir top paketinin ne kadar olduğunu bakarım. onu üçle çarpar raketide bulurum ve top+raket =fiyatı.
2	
3	A= 3 top paketinin bir tenise eşit oldubiliyorsam toplamını 2ye bölüp 3 bölerim 1 top paketenin kaç TL olduğunu bulurum
4	a) 3 top takımının fiyatı ile bir raket eşit olduğu için toplam 6 top takımı var gibi düşünürüm. sonra toplam fiyatı 6 ya böler ve 1 top takımını bulurum. onuda 3 ile çarpar ve bir tenis raketini bulurum.

Table 4.13 Scoring of Students' Response for part b of the 5th Problem

Scoring	Response
0	
1	b) a şıkkında zaten bildiğimize gore parasından çıkartırız ve sonucu buluruz.
2	b)parasından raket fiyatını çıkarırız
3	
4	

When the first pictures of Tables 12 and 13 were examined, it can be said that there was no apparent understanding of the fifth problem, and it was scored as 0. In second pictures of Tables 12 and 13, it is understood that students did not realize given in the problem. For instance, in the second picture from Table 12, students found the total price of the ball sets and racket instead of finding the cost of the ball set and racket separately. Also, in the other second picture from Table 13, students did not specify what they knew and what they subtracted from tennis player's money. These kind of responses scored as 1 since they reflects few understanding from the problem. Moreover, the third picture from Tables 12 and 13 shows that some students began with a correct plan, but they did not carry out far enough to

reach all the asked in the problem. These responses reflect a significant understanding of the problem, and they were scored as 2. In addition to that, if the students response was scored as 3 such as the forth pictures from Tables 12 and 13, they did not specify or label what they found in each step. Lastly, in fifth pictures from Tables 12 and 13, students gave appropriate plan in terms of formulate the given in the problem, and they explained all the steps of the plan in detail. These kinds of responses increased in posttest and retention test.

In brief, most of the students had difficulty in pretest because of focusing numbers by finding numbers. The ill-structured problems were found unusual by the participants since there were not consist of numbers, contrary to problems in mathematics. Most of the students had difficulty in forth problem, and the percentages of scores 3 and 4 were lower when it was compared with other problems in pretest, posttest, and retention test. Also, when the percentages of posttest and retention test results were compared with the pretest, the number of students who gave an appropriate plan and explained each step of their plan in detail increased.

4.2 Inferential Statistics Results of the ISPST

One of the goals of the current study was to examine whether there is a change in 5^{th} grade students' mathematical problem solving performance scores over three time periods. This research question was analyzed by comparing the mean scores of ISPST under three-time intervals by one-way repeated measures ANOVA. Before running the analysis, the assumptions were controlled and reported in the following sections.

4.2.1 Assumptions of One-Way Repeated Measures ANOVA for ISPST

The one-way repeated measures ANOVA assumptions were level of measurement, independence of observations, and normal distribution (Pallant, 2011).

4.2.1.1 Level of Measurement

According to Pallant (2011), in a research, the dependent variable requires continuous scale instead of discrete categorizes. In this study, dependent variables, which were student scores of ISPST, were measured under three-time intervals as pretest, posttest, and retention test, so this assumption was assured.

4.2.1.2 Independence of Observations

According to Pallant (2011), each observation or measurement was not affected, and they must be independent of one another. In the current study, this assumption was satisfied, and the observations were collected independently.

4.2.1.3 Normal Distribution

Pallant (2011) stated that if the sample size was large enough, more than 30, the violation of normality is not any major problem. In this study, there were 31 participants, and normality should not affect the conducting of analysis. Also, for this assumption, skewness and kurtosis values of ISPST were controlled for pretest, posttest, and retention tests. Table 4.14 presents skewness and kurtosis values of ISPST.

Table 4.14 Skewness and Kurtosis Values of ISPST

Instrument	Skewness	Kurtosis	Number of Participants
Pre-ISPST	,659	-,684	31
Post-ISPST	-,327	-1,401	31
Retention-ISPST	-,737	-1,056	31

According to Pallant (2013), skewness and kurtosis values are between -2 and +2 with a large enough sample size. As seen in Table 4.15, skewness and kurtosis values were between -2 and +2, and the distribution was close to normal. Moreover, the sample size over 30 and the normality assumption were assured for the current study besides ensuring skewness and kurtosis values.

4.2.2 The Result of One-Way Repeated Measures ANOVA for ISPST

After investigating the descriptive statistics results of ISPST, one-way repeated measures ANOVA was used to analyze the change in 5^{th} grade students' mathematical problem solving performance scores over three time periods. The null hypothesis of the first research question for ISPST stated that there is no statistically significant change in 5^{th} grade students' mathematical problem solving performance scores across three time periods (pre-ISPST, post-ISPST, and retention-ISPST).

Table 4.15 Descriptive Statistics for 5th Grade Students' Problem-Solving Performance Scores for Pre-ISPST, Post-ISPST and Retention-ISPST

Time Period	N	Mean	Standard Deviation
Pre-ISPST	31	8,52	7,42
Post-ISPST	31	15,29	7,51
Retention-ISPST	31	15,84	7,73

When Table 4.15 is examined, it is seen that ISPST posttest scores of the 5th grade students are higher than ISPST pretest scores, and ISPST retention test scores of the 5th grade students are higher than ISPST pre-test scores. Moreover, Figure 4.6 is given in below shows that the mean scores of ISPST over three time periods (Time 1: Pre-ISPST, Time 2: Post-ISPST, Time 3: Retention-ISPST).

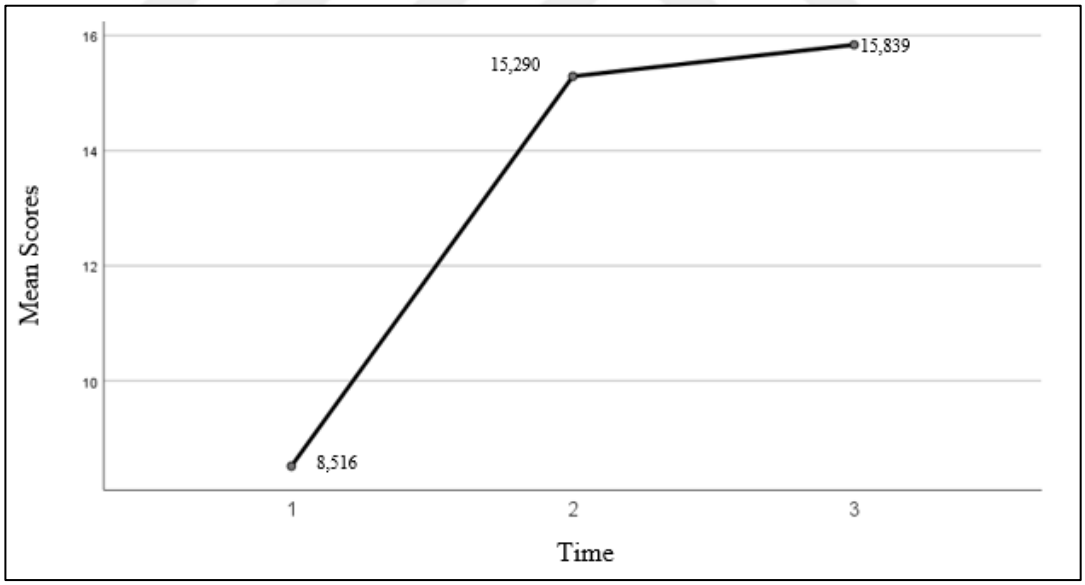


Figure 4.6. *Mean Scores of ISPST over Three Time Periods*

A one-way repeated ANOVA was conducted to compare scores on 5th grade students' mathematical problem solving performance scores for pre-ISPST, post-

ISPST and retention-ISPST. The mean and standard deviation are showed in Table 4.15. Also, Table 4.16 represents the multivariate test results, and Wilk' Lambda was used for the reporting. There was a significant effect for time, Wilks' Lambda = .30, F (2,29) = 33.41, P<0,005, multivariate partial eta squared = .70.

Table 4.16 The Values Related to Wilks' Lambda

Effect	Value	F	Sig.	Partial Eta Squared
Wilks' Lambda	.30	33.41	.000	.697

The study had a significant difference between the students' mathematical problem solving performance scores under the three-time periods, and the value of partial eta squared which is the effect size of this result was .70. According to Cohen (1988), this result indicates a very large effect size (.01=small, .06=moderate, .14=large effect). Bonferroni test was used for pairwise comparisons to determine which two of the students' mathematical problem solving performance scores were significantly different from the pretest, posttest, and retention test applications. Table 4.17 presents pairwise comparisons results of ISPST.

Table 4.17 Pairwise Comparisons of ISPST Scores of 5th Grade Students

Pairwise Comparisons						
					95 % Confidence Interval for Difference	
(I) Time	(J) Time	Mean Difference (I-J)	Std. Error	Sig.	Lower	Upper
1	2	−6.774	.820	.000	−8.854	−4.695
1	3	−7.323	1.032	.000	−9.940	−4.705
2	3	−.548	.636	1.000	−2.160	1.063

1: Pre-ISPST, 2: Post-ISPST, 3: Retention-ISPST

When the results in Table 4.17 are examined, it is seen that the students mathematical problem solving performance pretest-posttest and retention test scores of the 5th grade students differ statistically. In other words, the statistically significant change was observed in students' mathematical problem solving performance scores between pre-ISPST and post-ISPST, and between pre-ISPST and retention-ISPSTas well. Otherwise, it was also found that there was no statistically significant change in students' scores between post-ISPST and retention ISPST. However, by examining Figure 4.6, it was observed that the performance grades of the students have increased, albeit slightly. However, the significant difference between the pretest-retention test mathematical problem solving performance scores explains that the students continue to use problem solving methods they have gained in intervention.

In brief, all these descriptive and inferential results suggest that problem solving instruction have an effect on students' mathematical problem solving performance scores. Especially, when the answers given by the students to the posttest and retention test after the answers in the pretest are examined, it can be said that the students look at the problem differently and try to develop different problem solving strategies.

4.3 Descriptive Statistics Results of the WSPST

The WSPST consisted of six well-structured problems under the five main ill-structured problems. This test was applied to students as pretest, posttest, and retention test. The focused holistic scoring point scale was conducted, and the range of points on this scale was 0-4. As suggested by Charles, Lester, and O'Daffer (1987), focused holistic scoring was used while calculating the mathematical problem solving performance of students in solving well-structured problems. In focused holistic scoring, students' entire solution of each well-structured problem is scored by the thinking processes involved in solving the problem. Also, the criteria for each assigning point were modified by the researcher

examining students' solutions in the pilot study of WSPST. Thus, the maximum score students can have in WSPST was 24, and the minimum score was 0. The descriptive statistics of the tests are given in Table 4.18. The following table summarizes the descriptive statistics gathering from the pre, post, and retention tests.

Table 4.18 Descriptive Statistics Results of the Pre-WSPST, the Post-WSPST and the Retention WSPST

	Pre-WSPST	Post-WSPST	Retention-WSPST
N	31	31	31
Mean	13.97	18.03	18.42
Std. Deviation	6.295	5.600	5.644
Minimum	2	5	5
Maximum	24	24	24

As seen in the table, the mean score of the pretest was 13.97 (SD= 6.295), the mean score of the posttest was 18.03 (SD= 5.600), and the mean score of the retention test was 18.42 (SD= 5.644). Considering these results, it can be said that the mean score of the post and retention tests were higher than the mean score of pretest.

Responses of students and percentages of grades for each problem in pre-, post- and retention WSPST are given below in detail.

Problem 1

The first problem's objectives were about comprehending the difference between the concept of "greater than" and "less than." The problem is given in Figure 4.7, and the the percentages of these scores are given in Table 4.19.

There is only dark and white chocolate in a chocolate shop. Of the same size chocolates, the number of white chocolates is 146 fewer than the number of dark chocolates. If the number of white chocolates is 362, how many dark and white chocolates are in total in the chocolate shop?

Figure 4.7. *1st problem in WSPST*

Table 4.19 Percentages of scores for the 1st Problem of the WSPST

	Pre-WSPST	Post-WSPST	Retention-WSPST
0	3.2%	0%	0%
1	9.7%	16.1%	9.7%
2	22.6%	25.8%	16.1%
3	12.9%	16.1%	12.9%
4	51.6%	41.9%	61.3%

More than half of the students got the score of four from this problem in the pretest. A common misunderstanding of the students related to this problem was matching the word ‘fewer’ to subtractions. Because of this reason, some of the students thought that they would remove the lesser part of the white chocolate from the white chocolote to find the number of dark chocolate. In the posttest, the score of 4 decreased compared with the pretest, since some of the students thought that 362 was the total number of the chocolates instead of white chocolate. In figure 4.8, there is an example of one of the student’s response for this misunderstanding.

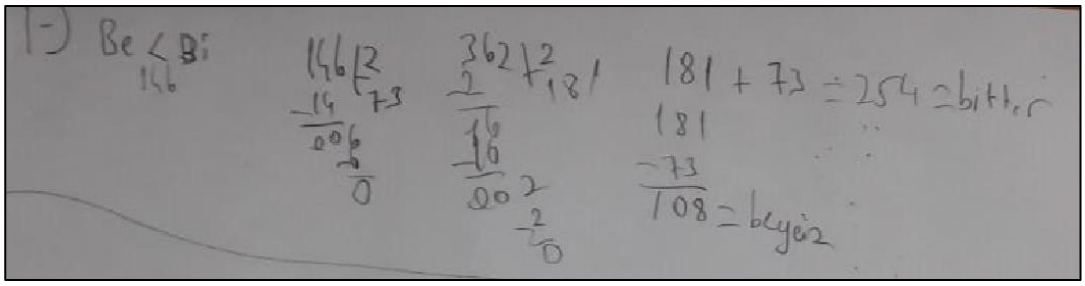
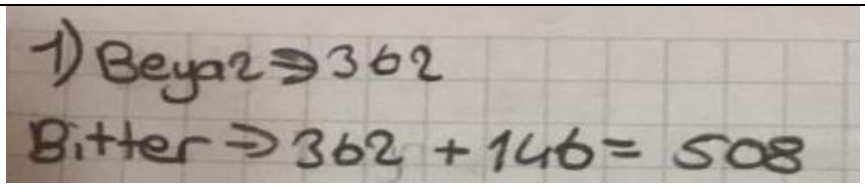
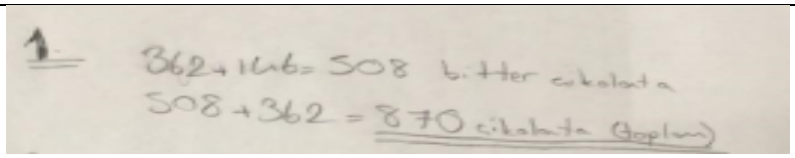


Figure 4.8. *Students' response from the post-WSPST for 1st problem*

The students, who took 362 as the total number of chocolates in the posttest, gave the correct answer in the pretest, but in the posttest, they used the strategy used in the fourth problem in ISPST. It is understood that some of the students skipped some of the steps of problem solving, which were understanding the problem and checking the solution. Also, when examining these students' solutions, most of them gave the correct answer in the retention test as the pretest. This response can be memorizing the strategy in problem solving instruction and copying that to the posttest. Table 4.20 presents examples from the students' solutions and scoring.

Table 4.20 Scoring of Students' Response for the 1st Problem

Scoring	Response
0	When students leave blank or there is an incorrect answer and no other work is shown., the answer scored as 0.
1	362-146 eşittir 216
2	362-146= 216 216+362= 578 toplam çikolata
3	
4	

As seen in Table 4.20, a common misconception of the word fewer means subtraction was scored as two because the students used an inappropriate strategy and got an incorrect answer, but the work showed some understanding of the problem, and they made addition to find total number of chocolates. However, when students just used subtraction and found 216 without any explanation, it was scored as 1. Moreover, the student who took 3 score has implemented a solution strategy that could have led to the correct solution. Still, they ignored a condition in the problem, and they did not find the total number of chocolates. When students got a score of 4, they gave the correct answer was given in terms of the data in the problem and labeled calculation correctly.

Problem 2

The second problem's objectives were about interpreting a situation of "twice as many, three times as many as, four times as many as etc." The problem is given in Figure 4.9, and the percentages of these scores are given in Table 4.21.

The number of female students in a class is four times that of male students. Since the number of female students is 21 more than the number of male students, find the total number of students in the class.

Figure 4.9. *2nd problem in WSPST*

Table 4.21 Percentages of scores for the 2nd Problem of the WSPST

	Pre-WSPST	Post-WSPST	Retention-WSPST
0	67.7%	32.3%	41.9%
1	9.7%	3.2%	3.2%
2	9.7%	12.9%	6.5%
3	3.2%	3.2%	6.5%
4	9.7%	48.4%	41.9%

Students had the most difficulty with the second problem in pre, post, and retention WSPST. As seen in Table 4.21, approximately seventy percent of students took the score of zero in pre-WSPST. After the problem solving instruction, the number of students who took 4 points increased from per to post WSPST. However, the number of students who retook four points increased from post to retention WSPST. Still, students were more successful when this decreased compared to the pretest result. A common misunderstanding of the second problem was that taking 21 as the number of female students, so most of the students tried to divide 21 into 4 to find the number of male students. After dividing 21 into 4, they reached the number with the decimal and showed the number of students in class with the decimal number. The example of this kind of response was given in Figure in 4.10.

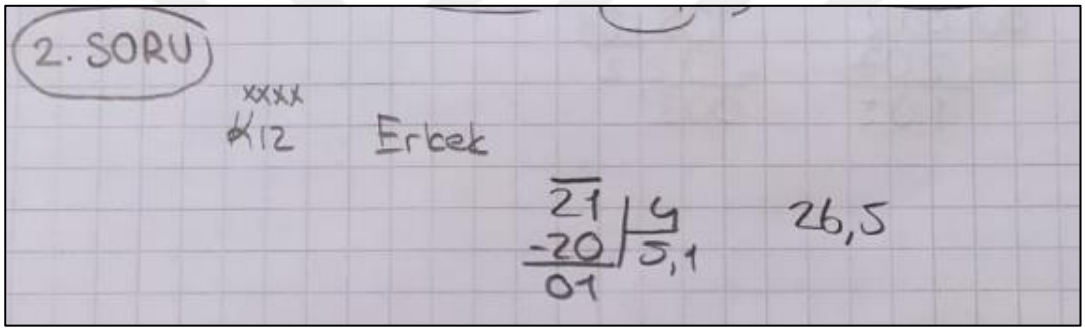


Figure 4.10. *Students' response for 2nd problem*

The biggest issue with these responses was that students did not convert mathematics to real life situations since they did not consider how such an answer as the number of total students could be possible. Table 4.22 shows examples from the students' solutions and scoring.

Table 4.22 Scoring of Students' Response for the 2nd Problem

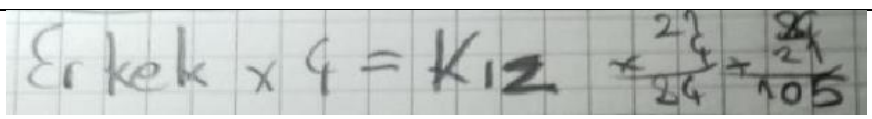
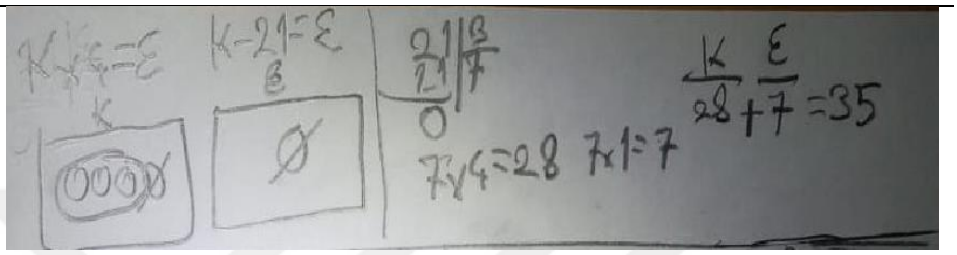
Scoring	Response
0	

Table 4.22 (Cont'd)

1	21÷4=5 (kalan 1)
2	21÷4=5 1arttı 5+1=6 erkek öğrenci 6+21=27kız öğrenci 6+27= 33
3	21/3=7 7+21=28 28=sonuç
4	

In the first picture in Table 4.22, common misconception of matching the word of times to the multiplication. These responses were scored as zero because there was work but no clear understanding of the problem. In the second and third pictures in Table 4.22, the students used an inappropriate strategy and got an incorrect answer, but the work showed some understanding of the problem. The responses like the third picture were scored as two since finding the total number of students was thought. Moreover, the student who took score of three has implemented a solution strategy that could have led to the correct solution. Still, they ignored a condition in the problem, and they did not find the total number of students. When students got a score of 4, they selected appropriate strategies and implemented them correctly.

Problem 3

The third problem's objectives were about comprehending the relationship between part and whole. The problem is given in Figure 4.11. The percentages of these scores are given in Table 4.23.

A stationery owner bought 960 balloons for 240 Turkish liras. He placed the balloons in packages with eight balloons in each package and sold all of the balloons. How much profit did the stationery owner make if he sold a pack of balloons for 4 liras?



Figure 4.11. *3rd problem in WSPST*

Table 4.23 Percentages of scores for the 3rd Problem of the WSPST

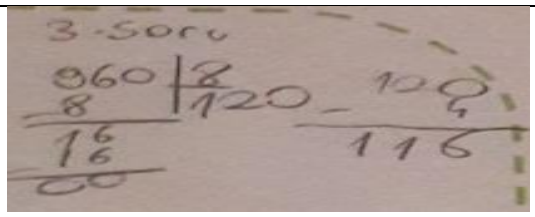
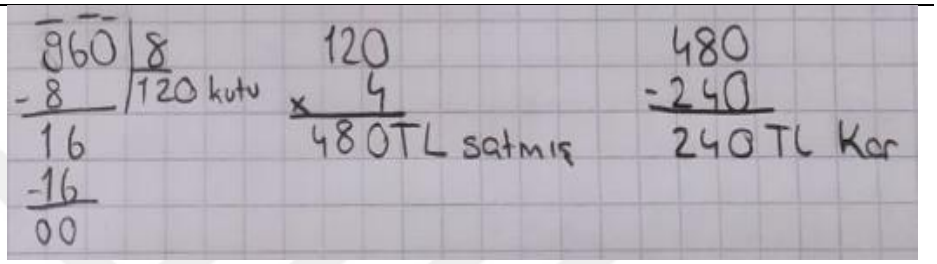
	Pre-WSPST	Post-WSPST	Retention-WSPST
0	16.1%	0%	0%
1	6.5%	0%	0%
2	3.2%	12.9%	12.9%
3	6.5%	3.2%	0%
4	67.7%	83.9%	87.1%

Most of the students' responses were scored as 4 in WSPST over three time periods. Also, its percentages increased from the pre-WSPST to retention-WSPST. In the third problem, some of the students divided 960 into 240, and they thought that its a balloon price. It can be said that some of the students had a common misconception that the larger number is always divided by the smaller number. Table 4.24 shows examples from the students' solutions and scoring.

Table 4.24 Scoring of Students' Response for the 3rd Problem

Scoring	Response
0	960x4=3840-968=2880
1	960/240=4 8*4=32 32-4=28 28 lira kar

Table 4.25 (Cont'd)

2	
3	960/8=120 120x4=480
4	

In pre-WSPST, some of the students had some operations, but there was no apparent understanding of the problem, and this kind of answer was scored as 0. In the second picture in Table 4.24, the students', who had a misconception explained above, response was scored as 1, since they believed that they found the balloon price dividing 960 into 240 and tried to find price of package. It is understood that they reflected some understanding for the problem. Moreover, in pretest some of the students just found the number of packages, and they did not label what they found so these responses were scored as 2. In the fourth picture of Table 4.24, some of the students ignored the calculate the profit so these responses were scored as 3. Biggest part of the students chose the correct strategy and implemented it correctly in WSPST over three periods, and their answers were 4.

Problem 4

The forth problem's objectives were about comprehending the difference between concept of "greater than" and "less than". The problem is given in Figure 4.12. The percentages of these scores are given in Table 4.25.

Kinyas and Kayra will share 480 marbles in a bag. Since Kayra bought 82 less than Kinyas, find the number of marbles each of them got.

Figure 4.12. *4th problem in WSPST*

Table 4.25 Percentages of scores for the 4th Problem of the WSPST

	Pre-WSPST	Post-WSPST	Retention-WSPST
0	16.1%	0%	3.2%
1	16.1%	3.2%	0%
2	35.5%	51.6%	58.1%
3	0%	0%	0%
4	32.3%	45.2%	38.7%

In the fourth problem, most of the students had difficulty, and the reason for the difficulty was that they skipped the last step of Polya's problem solving step, which was checking the solution. The common misunderstandings presents in Figure 4.13 and 4.14 for the fourth problem.

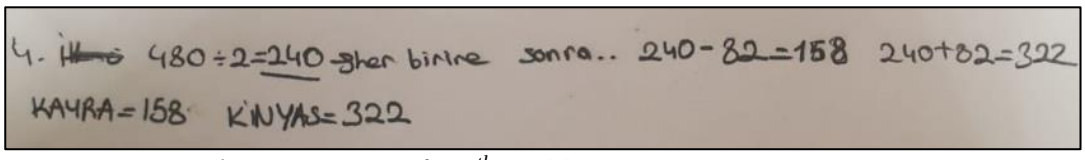


Figure 4.13. *Students' response for 4th problem*

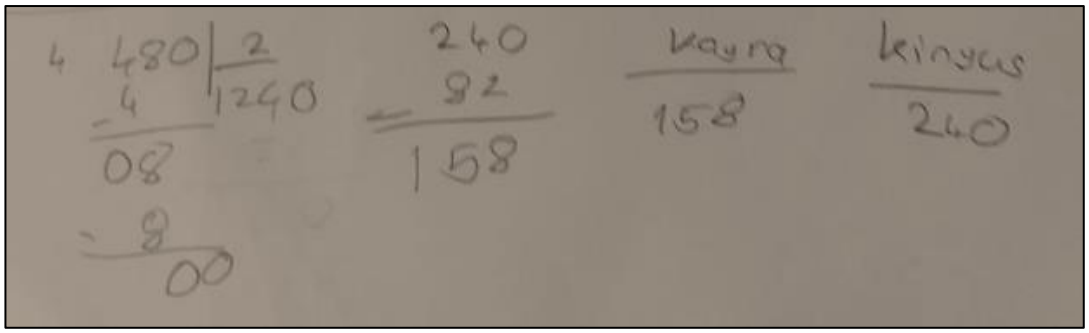


Figure 4.14. *Students' response for 4th problem*

In figure 4.13, students kept the total number of marbles fixed, but they substracted the lesser part from adding the other one. Thus, they doubled the marbles difference between Kayra and Kinyas. If the students controlled their answers, they could see the difference doubled. These kinds of responses were scored as 2. As seen in Table 4.25, more than half of the students had this misunderstanding in post and retention WSPST. In Figure 4.14, students kept the difference of the number of marbles fixed between Kayra and Kinyas, but they changed the total number of marbles. The students did not pay attention that Kinyas took half of the marbles, but Kayra's marbles were less than half. That is to say; students did not realize that they had changed the whole, so it was scored as 1. On the other hand, the score of 4 increased from the pre to post WSPST, and it closed half of the students. From the post to retention WSPST, the score of 4 decreased but was still higher than pre-WSPST.

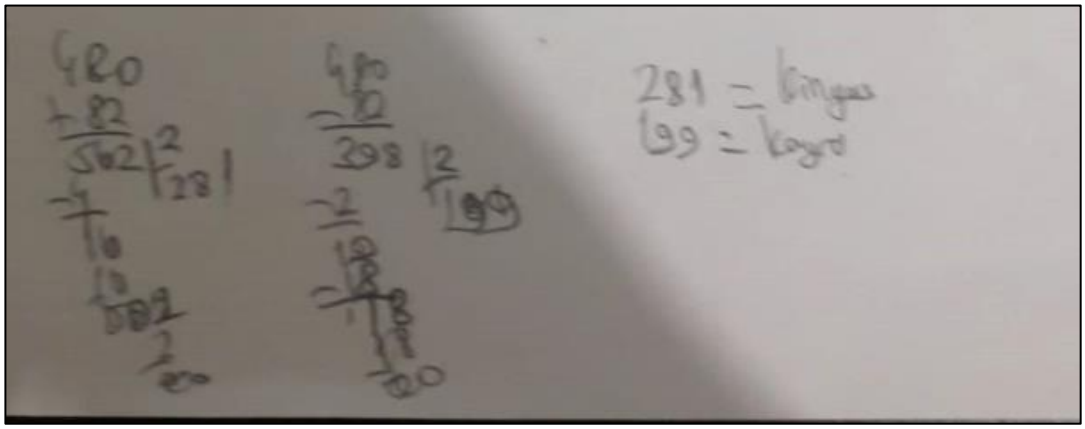


Figure 4.15. *Students' response for 4th problem*

In figure 4.15, it was given an example response for the score of 4. Some of the students used the strategies learned in the problem solving instruction.

Problem 5

The fifth problem's objectives were about interpreting a situation of "twice as many, three times as many as, four times as many as, etc." and comprehending the relationship between part and whole while solving the problem. In fifth problem, there were two sub-items. The problem is given in Figure 4.16.

In the fifth problem, students' solutions were graded as 0-4 for each part a and b of the problem. The percentages of these scores are given in Table 4.26 and 4.27 for part a and b of the problem.

In a store, the total price of the sleeping bags given in the picture is equal to the price of the tent.



a) If the total price of the tent and sleeping bags in the picture is 416 liras, how much is the price of a tent and a sleeping bag?

Price of tent: .....

Price of a sleeping bag: .....

b) A customer who came to buy camping equipment received a tent and several sleeping bags in the picture. If the customer paid 312 liras for the tent and sleeping bags he bought, how many sleeping bags did he buy?

Figure 4.16. *5th problem in WSPST*

Table 4.26 Percentages of scores for part a of the 5th Problem of the WSPST

	Pre-ISPST	Post-ISPST	Retention-ISPST
0	25.8%	12.9%	16.1%
1	0%	6.5%	0%
2	9.7%	3.2%	0%

Table 4.26 (Cont'd)

3	9.7%	0%	3.2%
4	54.8%	77.4%	80.6%

Table 4.27 Percentages of scores for part b of the 5th Problem of the WSPST

	Pre-ISPST	Post-ISPST	Retention-ISPST
0	38.7%	22.6%	16.1%
1	0%	0%	0%
2	6.5%	0%	0%
3	0%	3.2%	0%
4	54.8%	74.2%	83.9%

As seen in Tables 4.26 and 4.27, more than half of the students' responses were scored as 4 in pre-WSPST. When the percentages of results were compared, students made progress, and the score of four increased from the pretest to the retention test. It is understood that students did not have difficulty with the fifth problem. In the pre-WSPST, some of the students showed partial understanding for the fifth prıblem, and their answer was scored as 2. The misunderstanding in this problem was related to the sentence at the beginning of the problem which the total price of the sleeping bags given in the picture equals the price of the tent. In other words, they had difficulty with the concept of "equality". They inferred that there were five products in Figure 4.16 and all had the same price, and they divided the total price of the tent and sleeping bags in the picture into 5. Moreover, the other misunderstanding was that 416 equals the cost of the four sleeping bags, and students comprehend that price of a tent is equal to the price of one sleeping bag. Figure 4.17 and 4.18 are given as the examples of this response .

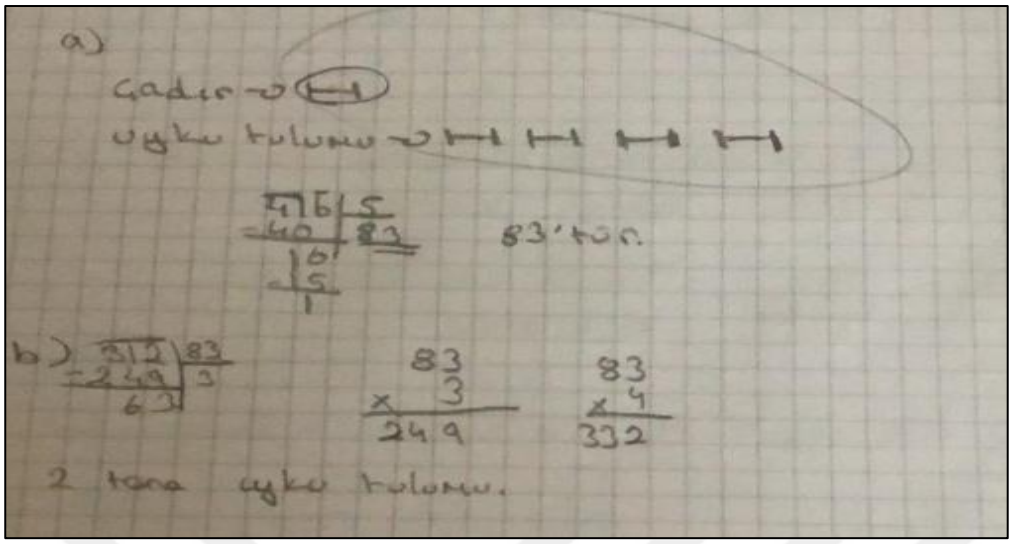


Figure 4.17. *Students' response for 5th problem*

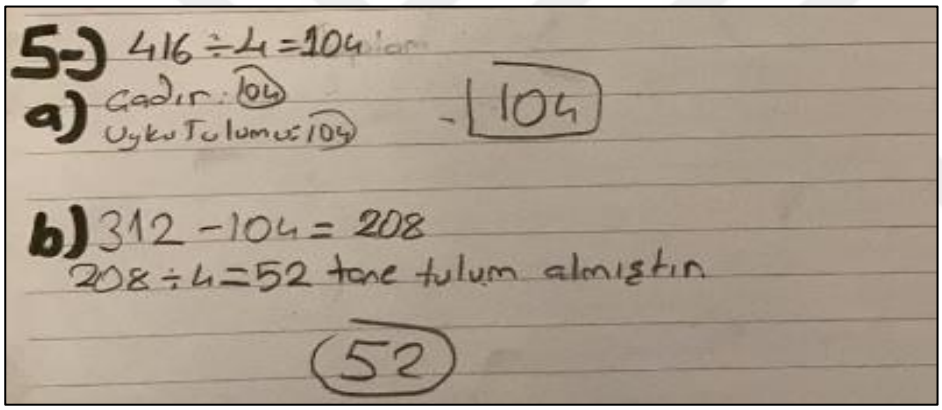


Figure 4.18. *Students' response for 5th problem*

As seen in Figure 4.17, some students thought that one sleeping bag price was equal to one tent price, so they maintained the same misunderstanding about part b. An appropriate strategy was used, but it was implemented incorrectly due to finding incorrect answers for the previous item of the problem. Because of this reason, part b of the problem was scored as 2 in Figure 4.17. Also, some of the students' responses were scored as 3 in post-WSPST since they did not specify or label what they found. For instance, they found 208 and 52 for the first part of the problem, but they did not write which one belonged to a tent or sleeping bag. Lastly, most of the students used appropriate strategies and implemented them

correctly, so their responses were scored as 4 in each part of the fifth problem. Figure 4.19 is given as an example of this response.

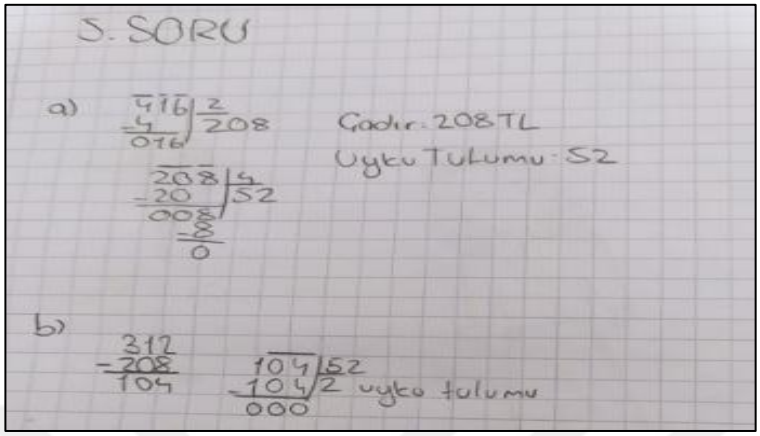


Figure 4.19. *Students' response for 5th problem*

In short, when the percentages of posttest and retention test results were compared with the pretest, the mean score of post and retention WSPST increased. Most of the students had difficulty in the second and fourth problems, and misconceptions related to these problems continued in the retention test. Although some students overcome these misconceptions in post-WSPST, the retention test results showed that some of them returned to these misconceptions.

4.4 Inferential Statistics Results of the WSPST

To examine whether is there a change in 5th grade students' mathematical problem solving performance scores over three time periods in WSPST, one-way repeated measures ANOVA was conducted. Before running the analysis, the assumptions were checked and reported in the following sections.

4.4.1 Assumptions of One-Way Repeated Measures ANOVA for WSPST

The one-way repeated measures ANOVA assumptions were level of measurement, independence of observations, and normal distribution (Pallant, 2011).

4.4.1.1 Level of Measurement

According to Pallant (2011), the dependent variable requires a continuous scale instead of a categorical one since they provide possible techniques for analyzing the data. In this study, dependent variables, which were student scores of WSPST, were measured under three-time intervals, so this assumption was assured.

4.4.1.2 Independence of Observations

According to Pallant (2011), each observation or measurement must be independent of the other. In the current study, this assumption was satisfied, and the observations were collected independently.

4.4.1.3 Normal Distribution

According to Pallant (2011), the sample chosen from the population should be distributed normally. In current study, there were 31 participants, and normality should not affect the conducting of analysis. However, to ensure normality for this assumption, skewness and kurtosis values of WSPST were checked for pretest, posttest, and retention tests. Table 4.28 demonstrates skewness and kurtosis values of WSPST.

Table 4.28 Skewness and Kurtosis Values of WSPST

Instrument	Skewness	Kurtosis	Number of Participants
Pre-WSPST	,349	-,720	31
Post-WSPST	-1,114	,121	31
Retention-WSPST	-1,166	,376	31

Table 4.28 presents that skewness and kurtosis values were between -2 and +2, and the distribution was close to normal, according to Pallant (2013). Besides ensuring skewness and kurtosis values, the sample size was 31, and the current study assured the normality assumption.

4.4.2 The Result of One-Way Repeated Measures ANOVA for ISPST

A one-way repeated measures ANOVA was conducted for WSPST to determine whether the 5th grade students' mathematical problem solving performance pre-test scores differed. The null hypothesis of the first research question for WSPST stated that there is no statistically significant change in 5th grade students' mathematical problem solving performance scores across three time periods (pre-WSPST, post-WSPST, and retention-WSPST).

Table 4.29 Descriptive Statistics for 5th Grade Students' Problem-Solving Performance Scores across Pre-WSPST, Post-WSPST and Retention-WSPST

Time Period	N	Mean	Standard Deviation
Pre-ISPST	31	13,97	6,295
Post-ISPST	31	18,03	5,600
Retention-ISPST	31	18,42	5,644

When Table 4.29 is examined, it is understood that post and retention WSPST scores were higher than pre-WSPST scores. Also, students continued to increase their scores in the retention test compared to the post-test scores, albeit a little. Additionally, Figure 4.20 presents the mean scores of WSPST over three time periods (Time 1: Pre-WSPST, Time 2: Post-WSPST, Time 3: Retention-WSPST)

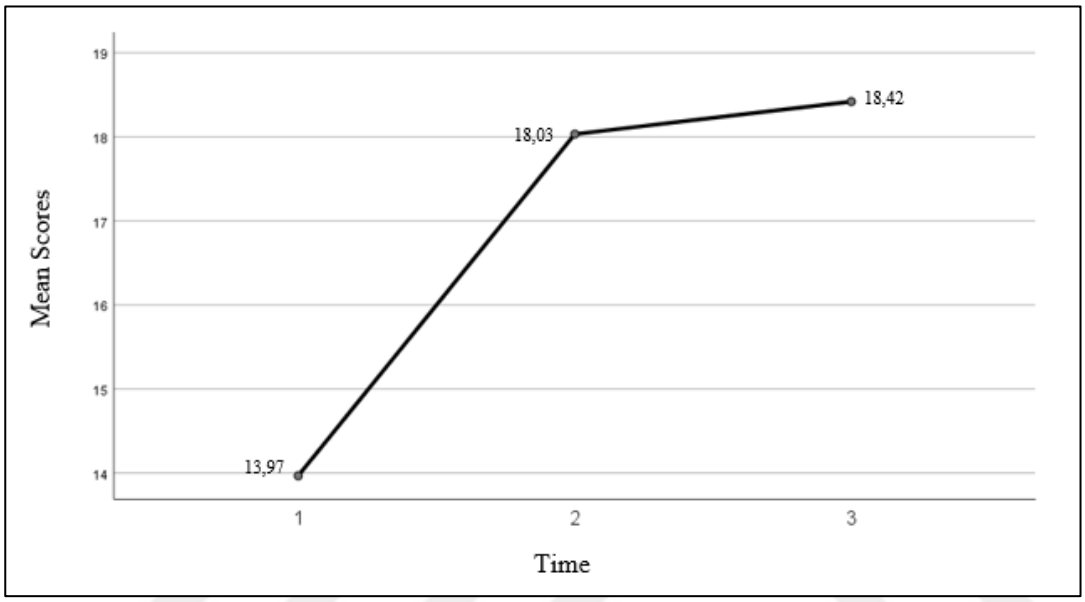


Figure 4.20. *Mean Scores of WSPST over Three Time Periods*

A one-way repeated ANOVA was conducted to compare scores on 5th grade students' mathematical problem solving performance scores for pre-WSPST, post-WSPST and retention-WSPST. The mean and standard deviation are showed in Table 4.29. Also, Table 4.30 represents the multivariate test results, and Wilk' Lambda was used for the reporting. There was a significant effect for time, Wilks' Lambda = .34, F (2,29) = 28.41, P<0,005, multivariate partial eta squared = .66.

Table 4.30 The Values Related to Wilks' Lambda

Effect	Value	F	Sig.	Partial Eta Squared
Wilks' Lambda	.328	28.41	.000	.662

The study shows that there was a significant difference between the students' mathematical problem solving performance scores across the three time periods and the value of partial eta squared. The effect size of this result was .66. According to Cohen (1988), this result indicates a very large effect size (.01=small, .06=moderate, .14=large effect). The Bonferroni test was used to determine which pairs of periods (pre, post, and retention) caused the mean difference. Table 4.31 gives pairwise comparisons results of WSPST.

Table 4.31 Pairwise Comparisons of WSPST Scores of 5th Grade Students

Pairwise Comparisons						
(I) Time	(J) Time	Mean Difference (I-J)	Std. Error	Sig.	95 % Confidence Interval for Difference	
					Lower	Upper
1	2	−4.065	.622	.000	−5.642	−2.487
1	3	−4.452	.584	.000	−5.934	−2.970
2	3	−.387	.395	1.000	−1.390	.615

1: Pre-WSPST, 2: Post-WSPST, 3: Retention-WSPST

When the results in Table 4.31 are examined, it is seen that the statistically significant change was observed in students' mathematical problem solving performance scores between pre-WSPST and post-WSPST and between pre-WSPST and retention-WSPST as well. On the other hand, it was also observed that there was no statistically significant change in students' scores between scores of post and retention WSPST. However, by examining Figure 4.20, it was observed that the performance grades of the students have increased from the post to retention, albeit slightly.

In short, all these descriptive and inferential results of WSPST suggest that PSI has a discernible effect on students' mathematical problem solving performance scores. The descriptive results show that students had some misconceptions, and their reasons were examined. In post and retention WSPST, some of the students

overcame those misconceptions since the score of 3 and 4 was increased in most of the well-structured problems. Also, inferential statistics state a statistically significant change in 5th grade students' problem solving scores from pre to post and retention WSPST.

4.5 Descriptive Statistics Results of ISPST and WSPST for the Posttests and Retention Tests

In this part of the research, the second research question was examined, and it was "Is there a relationship between the fifth-grade students' problem solving scores of ill-structured and well-structured problems solving tests at posttests and retention tests?" Descriptive results of ISPST and WSPST for posttests and retention tests were examined detailly in sections 4.1 and 4.3, respectively. Table 4.32 summarizes the descriptive results of ISPST and WSPST for posttests and retention tests.

Table 4.32 Descriptive Statistics Results of ISPST and WSPST for posttests and retention tests

	Post-ISPST	Retention-ISPST	Post-WSPST	Retention-WSPST
N	31	31	31	31
Mean	15.29	15.84	18.03	18.42
Std. Deviation	7.51	7.73	5.600	5.644
Minimum	2	2	5	5
Maximum	24	24	24	24

Table 4.32 gives information related to sample, mean scores, standard deviation, minimum and maximum scores of ISPST and WSPST at posttests and retention tests. In the following section, inferential statistics of these tests' results was examined by conducting the Pearson Product-Moment Coefficient of Correlation.

4.6 Inferential Statistics Results of ISPST and WSPST for the Posttests and Retention Tests

Pearson Product-Moment Coefficient of Correlation was utilized to determine the relationship between students' mathematical problem solving performance scores of ISPST and WSPST for posttests and retention tests.

4.6.1 The Relationship between Problem-Solving Performance Scores of ISPST and WSPST for Posttests

In PSI, participants first solved ill-structured problems and then continued with a well-structured version of these problems. The purpose of the correlation study is to show any relationship between the ISPST and WSPST results and, if so, present the strength and direction of the relationship between these scores. Before conducting the analysis, assumptions were checked, and the assumptions are level of measurement, related pairs, independence of observation, normality,linearity. Some of the assumptions which were level of measurement, independence of observation and normality were checked for post-ISPST and post-WSPST in previous section in 4.2.1 and 4.4.1, respectively. For the assumption of related pairs, it can be said that scores were taken from the same participants in both tests. Moreover, to check the linearity and homoscedasticity assumption, Figure 4.21 illustrates the relationship between problem solving scores of post-ISPST and Post-WSPST.

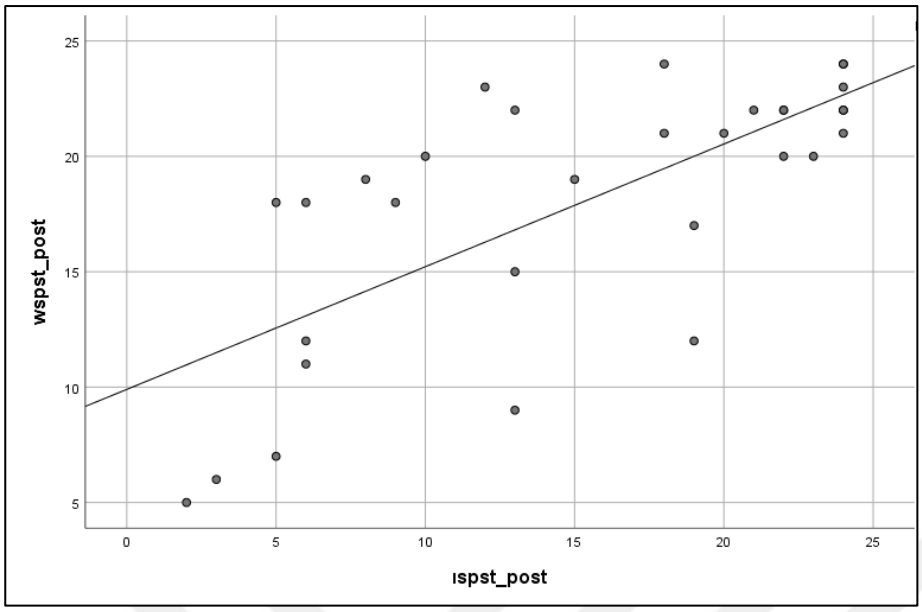


Figure 4.21. *Scatterplot of Problem-Solving Performance Score of post-WSPST and post-ISPST*

As seen from Figure 4.21, the linearity assumption is provided. Since the scores' variability for both tests are similar and spread in a cigar shape, a homoscedasticity assumption is provided (Pallant, 2013). All the assumptions were checked, it was found that there were no violations. After the controlling assumptions, Pearson Product-Moment Coefficient of Correlation was utilized, and the results of this analysis was given in Table 4.33.

Table 4.33 Results of Pearson Product-Moment Coefficient of Correlation of Problem-Solving Performance Scores for post-WSPST and post-ISPST

		Post-ISPST	Post-WSPST
Post-ISPST	Pearson Correlation Sig. (2-tailed)	1	,713(**)
			,000
	N	31	31
Post-WSPST	Pearson Correlation	,713(**)	1
	Sig. (2-tailed)	,000	
	N	31	31

According to Pallant (2013), the value of the correlation coefficient range from -1 to +1. The value of -1 shows a perfect negative correlation, 0 indicates no relationship, and +1 represents a perfect positive relationship between two variables. Additionally, Cohen (1988) states that if the value of the correlation coefficient is between 0,50 and 1, there is a large correlation between two variables.Table 4.33 revealed there was a strong positive correlation between problem solving scores of post-ISPST and post-WSPST, $r = .713$, $n = 31$, $p < .05$. Moreover, the square of the correlation coefficient is nearly 50 percent, which means that quite a respectable amount of the variance is explained by the relationship between scores of post-WSPST and post-ISPST.

4.6.2 The Relationship between Problem-Solving Performance Scores of ISPST and WSPST for Retention Tests

Pearson Product-Moment Coefficient of Correlation analyses was conducted to show the relationship between the ISPST and WSPST results. Before conducting the analysis, assumptions of level of measurement, related pairs, independence of observation, normality, linearity, and homoscedasticity were checked. In 4.2.1 and 4.4.1 sections, assumptions of level of measurement, independence of observation and normality were controlled for retentions of ISPST and WSPST, separately. For each test, participants were the same, so the related pairs assumption was met. Also, Figure 4.22 represents scatterplots of problem solving scores of retentions of ISPST and WSPST to control the linearity and homoscedasticity assumptions.

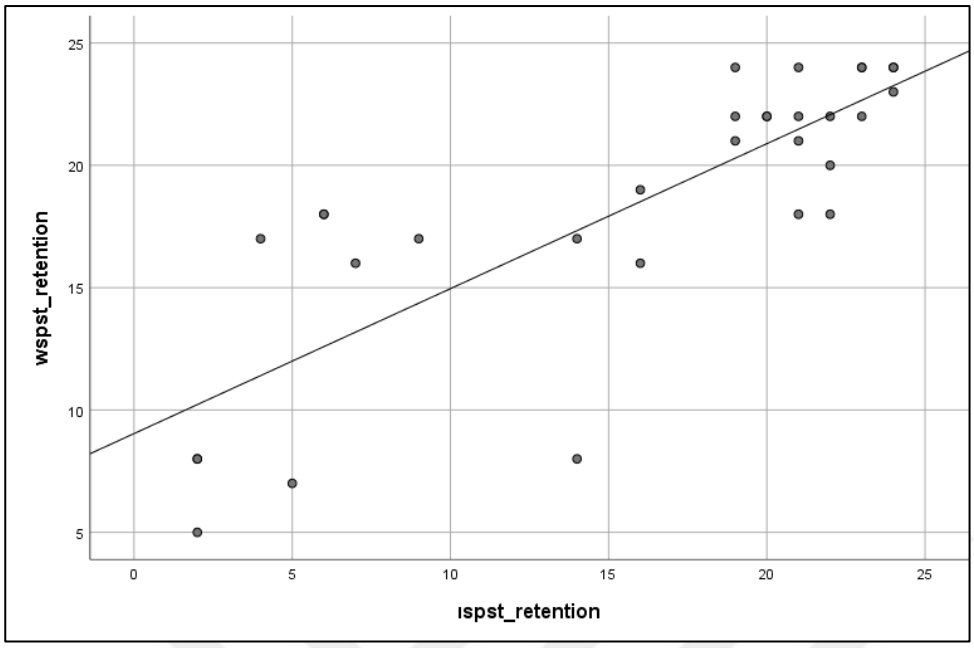


Figure 4.22. *Scatterplot of Problem-Solving Performance Score of retention-WSPST and retention-ISPST*

As seen from Figure 4.22, the linearity and homoscedasticity assumptions are provided since the distribution of scores is roughly linear, and the scores' variability for both tests is similar and spread in a cigar shape. After the providing all the assumptions, Pearson Product-Moment Coefficient of Correlation was utilized, and the results of this analysis was given in Table 4.34.

Table 4.34 Results of Pearson Product-Moment Coefficient of Correlation of Problem-Solving Performance Scores for retention-WSPST and retention-ISPST

		Retention-ISPST	Retention-WSPST
Retention-ISPST	Pearson Correlation Sig. (2-tailed)	1	,812(**) ,000
	N	31	31
Retention-WSPST	Pearson Correlation	,812(**)	1
	Sig. (2-tailed)	,000	
	N	31	31

Table 4.34 revealed that there was a strong positive correlation between problem solving scores of retentions ISPST and WSPST, $r = .812$, $n = 31$, $p < .05$. Because the correlation coefficient value was between 0,50 and 1, there was a large correlation between the two variables considering the suggestion of Cohen (1988). Moreover, the square of the correlation coefficient is nearly 66 percent, which means that quite a respectable amount of the variance was explained by the relationship between retention scores of WSPST and ISPST.

The findings Pearson Product-Moment Coefficient of Correlation showed that there was a strong positive relationship between mathematical problem solving performance scores of posts and retentions ISPST and WSPST. It can be said that as the 5^{th} grade students' ISPST scores increased, their WSPST scores also increased. In following section, inferences from this analysis will be supported by students' thoughts.

4.7 Implication Notes About Students' Thoughts on Problem Solving Instruction (PSI)

In the begginning of the study, the aim of Problem Solving Method Questionnarie is to reveal the thoughts of the students about instruction and problems. Since the students did not give detailed answers to the questions in the questionnaire applied at the end of the research, the results of this questionnaire could not be used in statistical analysis.

In the questionnaire, students began by explaining what came to mind when the word problem was mentioned, and they generally matched the problem to operations, numbers, and difficulties. After asking what the problem means to them, students answered the questions about advantages or disadvantages of the ill-structured problems, and whether ill-structured problems contribute to solving well-structured problems. Because of matching the problem to the numbers, students stated that the absence of numbers related to ill-structured problems

seemed difficult and complex at first. Also, the students said that making plans was the hard part of the process, and they initially had difficulties with this situation. On the other hand, the students generally expressed those ill-structured problems helped them gain a different perspective, understand the problem better, and develop more than one solution method. One of the students wrote, *"I used to only look at numbers while solving a problem, but since there are no numbers in ill-structured problems, I focus on what the problem wants to say and devise methods to solve it."* Moreover, one of the students wrote, "*Sometimes I solved the problem, but I couldn't answer when they asked how you did it. İll-structured problems helped me in this regard."* Additionally, most of the students stated that they learned how to start solving the problem and that a problem can have more than one solution method. They also specified that they really helped them understand the problem.

There were questions about whether solving ill-structured problems contributes to solving a well-structured problem in the questionnaire. A significant part of the students indicated that ill-structured problems positively impacted well-structured ones. For example, the students referred that they comprehended the problem deeply while solving ill-structured problems and developed more than one method. When they passed the well-structured problems, they knew the roads that followed, so they solved the well-structured ones faster and could control their response using more than one method. Moreover, students commented about PSI lessons, and they generally made positive comments about the instruction. They expressed that it was *"entertaining", "informative"* and *"enhancing perspective"*. One of the students wrote, *"Now I'm thinking about how I should solve the problem before I take action."* Also, one of them said, "*Since I am knowing what I am doing, the processes I do while solving the problem do not interfere."* Also, one of the students said, *"I received praise from my teacher for developing different perspectives on the questions asked in the mathematics lesson at school thanks to this lesson."*

To conclude, most of the students said they gained different perspectives about solving the problem. The students stated that they tried to understand the problem first and develop solution methods before focusing on the numbers in the problems. It is understood that PSI had positive impact on students.

CHAPTER 5

DISCUSSION, IMPLICATIONS AND RECOMMENDATIONS

The primary purpose of the current study was to investigate the effects of problem solving instruction on 5th grade students' mathematical problem solving performance across the three time periods. Also, the other aim of the study is to examine the relationship between 5th grade students' mathematical problem solving performance scores of WSPST and ISPST after the problem solving instruction. For these purposes, answers to the following research questions were sought.

1. Is there a change in 5th grade students' mathematical problem solving performance scores over three time periods?
2. Is there a relationship between the fifth-grade students' problem solving scores of ill-structured and well-structured problems solving tests at posttests and retention tests?

In this chapter, the study results will be summarized and discussed, and then implications and recommendations will be presented for further research.

5.1 Discussion of Results

The results of ISPST and WSPST, the relationship between these two tests, and students' thoughts about problem solving instruction will be discussed in this section.

5.1.1 Discussion on Problem-Solving Method Instruction

To results of the one-way repeated measures ANOVA showed that problem solving instruction have an effect on students' mathematical problem solving performance

scores of ISPST and WSPST. Hence, inferential statistics state a statistically significant change in 5th grade students' mathematical problem solving performance scores of ISPST and WSPST across three time periods. We can made inference that PSI might have created discernible effect on fifth garde students' mathematical problem solving performance scores. These findings support the other studies that understanding the problem is the most and a major part of the problem solving steps (Mayer, 1985; Saygılı, 2017; Verschaffel and De Corte, 1993), and importance of Polya's problem solving stages (Ulu, Tertemiz & Peker, 2016; Yıldız, 2008; Töre, 2007). In Ulu, Tertemiz, and Peker's (2016) research, the effect of reading comprehension and problem solving strategies training on students' problem solving success was examined. As a result of the study, a statistically significant impact emerged in favor of the students who exceeded the reading comprehension training. They drew an inference that this finding obtained as a result of the study allows them to see the importance of reading comprehension studies in problem solving education. Moreover, Verschaffel and De Corte (1993) investigated a study on elementary addition and subtraction problems. The current study also presents these kinds of problems related to these objectives. According to the result of research designing by Verschaffel and De Corte (1993), students who spend most of their time on understanding the problem have higher success in solving the problem. On the contrary, when students spent their most of their time focusing just numbers on the problems, they showed low academic success in the study. Hence, this research might be showed the importance of understanding the problems.

Another study that supports the findings of this study is that Hegarty, Mayer, and Mog (1995) studied on comparison of successful and unsuccessful problem solvers. Unsuccessful problem solvers focused on the solution plan using numbers and keywords such as "more, less, two times, three times, etc." selected from the problem sentence. They decided to act by looking at these keywords (For example, addition if it says more, subtraction if it says less, multiplication if it says two times, etc.). Students who were successful in problem solving examined the plot of

the problem rather than the words, analyzed the relationship between the givens and asked, and focused on the whole problem text. In the current study, while students were solving the ill-structured and well-structured problems in PSI, they first understood the problems, created more than one method, and applied these plans to the well-structured version of the problems. The results of Hegarty, Mayer, and Mog's study highlighted the significance of understanding the problems. After those previous studies of findings, it might be said that ill-structured problems had positive impact on understanding of the problem since they did not use numbers, by this way they tried to develop strategies to explain their solutions.

Along this line, many research studies have been conducted about the positive effects of problem solving on students' achievement in mathematics (Ulu, Tertemiz & Peker 2016; Yıldız 2008). In the study of Yıldız (2008), changing the 6th grade students' problems abilities were examined after the mathematics instruction based on Polya's problem solving stages. In the study, they just used an experimental group like this, and students solved the problem using Polya's stages during the semester. At the end of the study, Yıldız found that 6^{th} grade students' problem solving abilities significantly affected their instruction. Additionally, in the study of Töre (2007), Polya's problem solving steps were used in the qualitative study on the level of knowing and applying the problem solving process of 6th grade students. This study showed that most of the mistakes made in solving problems arise from the deficiencies in the step of reading and understanding the problem. According to Töre, to be a good problem solver, it is necessary to know Polya's steps completely and apply them correctly, to use a large part of the time to understand the problem and control what they do throughout the whole process. All in all, the result of previous research results revealed that based on Polya's problem solving steps, problem solving instruction might increase the students' mathematical problem solving performance.

In the current study, students' mathematical problem solving performance was analyzed for both the results of ISPST and WSPST separately. The results of ISPST were revealed that problem solving instruction has a statistically significant

effect on students' mathematical problem solving performance scores. When the answers given by the students in the posttest and retention test were compared with the solutions they shared in the pretest, it might be said that the students look at the problem differently and try to develop different problem solving methods. The results of the WSPST also were consistent with the ISPST results. In other words, inferential statistics stated a statistically significant change in 5th grade students' problem solving scores from pre to post and retention WSPST.

Along this line, when increasing the students' mathematical problem solving performance scores of ISPST and WSPST was examine, it might be said that problem posing effect the students' mathematical problem solving performance. Many studies have shown that problem solving and problem posing are interdependent and support each other (Silver, 1996; Stoyanova, 1997; Cankoy & Darbaz, 2010; Lin & Leng, 2007). Also, these studies showed that problem posing enhance students' problem solving skills.

When the descriptive results of the pre-ISPST and pre-WSPST were examined, and it showed that students had some misconceptions related to keywords selected from the problem. For example, while solving first problems of ISPSST and WSPST, some of the students focused on the keyword which is fewer, and they made subtraction. This result was consistent with the study of Verschaffel and De Corte (1993), and the study of Hegarty, Mayer, and Mog (1995). However, in post and retention ISPST and WSPST, it was shown that some of the students overcame those misconceptions, and this result may have been due to problem solving instruction.

Pearson Product-Moment Coefficient of Correlation was utilized to determine the relationship between students' mathematical problem solving performance scores of ISPST and WSPST for posttests and retention tests. According to current study's findings, there was a strong positive relationship between mathematical problem solving performance scores of posts and retentions ISPST and WSPST. It can be said that as the 5th grade students' ISPST scores increased, their WSPST scores also

increased. Moreover, Karaoğlan (2009) designed an experimental study to examine to effect of problem solving on students' mathematics achievement. Results shows instruction given in problem solving classes had substantial advantage on students' problem solving skills, and there was large positive correlation between students' problem solving and mathematics achievement. Therefore, in the current study, the high correlation might be due to the problem solving instruction designed by solving both ill-structured and well-structured problems.

5.1.2 Students' Thoughts about Problem Solving Instruction

The current study was conducted in the spring semester of the 2020-2021 academic year, and the students studied the subject of problems in the fall semester. That is to say; students had prior knowledge to solve problems with the traditional method. However, they had never solved or studied ill-structured problems before. The students were surprised and did not know what to do about solving problem. In both pilot study and the current study, the first reaction of most students was to solve the problem by giving numbers. During the PSI, students were first introduced to the problem solving steps of Polya, and then they started solving a problem with its ill-structured version. Since the ill-structured problem did not contain numbers, the students first tried to understand the problem and develop a solution method. After that, students continued with the well-structured version of the problem, and they applied their solution methods and checked their solution. Most of the students stated that they gained a different and effective point of view, and this study contributed a lot to their problem solving in PSI. They generally said that it was entertaining, informative, and enhancing perspective. It might be noted that PSI had positive impact on students. In the current study, the results of this questionnaire could not be used in statistical analysis.

However, previous studies findings show that problem solving, and Polya's problem solving stages brought positive behaviors to the students and enhanced their mathematical problem solving performance positively (Polat, 2009; Yıldız, 2008). Yıldız (2008) studied changing students' problem solving abilities and attitudes after the mathematics instruction based on Polya's problem solving stages students; students enjoyed solving the problem or discussing their methods related to the problem. This opinion was consistent with the findings of Polat (2009), who studied the effects of problem solving approaches on students' performance in mathematics; students stated that while solving the problem with the class discussion, they gained new ways of solution and looked at mathematics different perspectives. Likewise, in PSI, students discussed their methods with each other, and most of the students were able to express the method they developed to solve the problem without hesitation. As a result, students' mathematical problem solving performance might have been influenced by their enjoyment of solving the problem discussing with their friends and trying to develop different perspectives rather than focusing on numbers while solving problems.

5.2 Implications

The current study results revealed that after problem solving instruction, students had significant progress on mathematical problem solving performance. Also, their thoughts on PSI showed that they believed the instruction enhanced their points of view related to problem solving. Students generally focused on numbers at the beginning of the study, but the results revealed that students began to change their approaches to problem solving at the end of the study. Moreover, retention tests results showed that the effect of the PSI was permanent since students' problem scores did not decrease compared to the results of the posttest. In addition to that, the current research findings corroborated the previous studies regarding the positive impact of problem solving instruction based on Polya's phases.

The current research presents some implications for researchers, mathematics teachers and educators interested in mathematics. When the research report was examined, the implication of PSI was not difficult to apply since the method section implementations phase was explained in detail. Teachers or researchers can prepare own activity sheets, and lesson plan benefiting problems which were used in this study. Besides that, method and results sections showed that students' first reaction to ill-structured problems, how to overcome them and how to guide students in this process. For example, most of the students use numbers while solving the problem, and they try to use four operations without understanding the problem and making plans. The main contribution of the PSI to mathematics education is that using the ill-structured problem at the first stage may allow the student to think about the problem. To conclude, teachers and researchers should realize that this study reached the problem solving steps of Polya from a different place, and this study is entirely student-centered.

5.3 Recommendations

The present study was implemented from an online platform because of the pandemic. In future research, PSI can be conducted in the classroom settings in schools during school hours. Also, because of the pandemic, only one private school was reached, so there was a limited number of 5^{th} grade students. The research findings cannot be generalized to other schools so that further studies can be used in more than one school. Moreover, due to the limited number of students, there was the only experimental group in the research, so the researcher can be used a control group to reach the changes firmly in the future.

Future studies using qualitative or mixed methods can be conducted to examine the effect of PSI on mathematical problem solving performance in more depth. Besides that, different grade level students can be used to compare results of other grade levels could be made. Especially by providing this study at the primary school

level, students' prejudices against problems can be reduced, and different perspectives can be gained.

Since there are no numbers in ill-structured problems, the students understood and created different solutions strategies. Researchers or mathematics teachers may insist on using these problems. Moreover, implementation of PSI was given in detail so those who will implement it can benefit from the implementation stages. Since it is an important point for students to express their ideas in detail in this study, researchers and mathematics teachers should pay attention to this point.

In addition to that, because the students did not give detailed answers in problem solving questionnaire, no statistical analysis was performed on this questionnaire. In future studies, the researchers can be studied in this area, and they may interview students to get deeper information about students' thoughts. A qualitative study can be done with this data obtained from the students.

Moreover, I made use of real life situations while posing the problems since I wanted fifth graders to relate mathematics to real-life situations. They can also solve problems other than daily life problems in future studies, and ill-structured problems can be created with problems other than real-life situations at higher levels.

Finally, Polya’s problem solving stages were used in this study since fifth graders were familiar from the mathematics books. In the literature review section, I gave information about other cyclic problem solving models so this study can be applied with other models with more detailed problem solving steps.

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APPENDICES

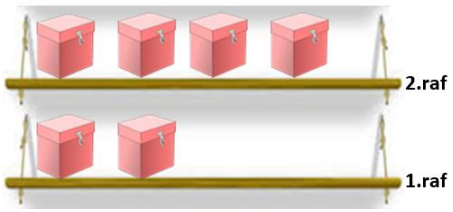
A. ILL-STRUCTURED PROBLEM-SOLING TEST (ISPST)

Problemleri çözerken uygulayacağınız yöntem veya yöntemleri detaylı olarak gösteriniz.

1) 

Bir okulda, Orman Haftası kapsamında ortaokul öğrencileri, yangında hasar görmüş ormanlık bir bölgeyi tekrar yeşillendirmek için ağaç dikme etkinliği düzenlemeye karar vermiştir. Bu etkinlik için öğrenciler belirli bir sayıda karaçam ve Toros Sediri dikeceklerdir. Dikilecek olan Toros Sediri sayısı, karaçamdan daha azdır.

Kullanılacak olan Toros Sedirinin sayısı ve Toros Sedirinin karaçamdan ne kadar az olduğu bilindiğine göre, etkinlikte kullanılacak olan toplam ağaç sayısını hangi yöntem veya yöntemlerle bulabiliriz? Yönteminizi detaylı bir şekilde açıklayınız.

2) 

Yanda verilen raflardaki kutuların içerisinde eşit sayıda dergi vardır. 1.raftaki dergi sayısının, 2.raftaki dergi sayısından ne kadar az olduğu bilindiğine göre, raflarda toplam kaç adet dergi olduğunu hangi yöntem veya yöntemlerle bulabiliriz? Yönteminizi detaylı bir şekilde açıklayınız.

3) Bir çiçekçi belirli bir miktar çiçeği yanda verilen resimdeki çiçek adedi kadar kullanarak buketler haline getiriyor. Çiçekçinin elindeki çiçek sayısı ve bir buketin fiyatı bilindiğine göre çiçekçinin bu buketlerden ne kadar kazandığını hangi yöntem veya yöntemlerle bulabiliriz? Yönteminizi detaylı bir şekilde açıklayınız.



4) Demir ve Yusuf'un karikatür dergisi koleksiyonları vardır. Yusuf'un dergi sayısı, Demir'in dergi sayısından azdır. İki arkadaşta toplam kaç dergi olduğu ve Yusuf'un dergi sayısının Demir'e göre ne kadar az olduğu bilindiğine göre, Demir ve Yusuf'un kaçar tane dergiye sahip olduğunu hangi yöntem veya yöntemlerle bulabilir? Yönteminizi detaylı bir şekilde açıklayınız.

5) Bir mağazada, şekilde verilen top takımlarının toplam fiyatı ile tenis raketinin fiyatı birbirine eşittir.



a) Top takımlarının ve tenis raketinin toplam fiyatı bilindiğine göre, raket ve bir top takımının fiyatının kaçar lira olduğunu hangi yöntem veya yöntemlerle bulabiliriz? Yönteminizi detaylı bir şekilde açıklayınız.

b) Tenisçinin belirli bir miktar parası vardır. Parasının tamamıyla şekildeki raketi ve birkaç top takımını alabilmektedir. Tenisçinin sahip olduğu para miktarı bilindiğine göre, raketle birlikte kaç top takımı aldığını hangi yöntem veya yöntemlerle bulabiliriz? Yönteminizi detaylı bir şekilde açıklayınız.

B. WELL-STRUCTURED PROBLEM-SOLVING TEST (WSPST)

Problemleri çözerken kullandığınız yöntem / yöntemleri ve işlemleri detaylı olarak açıklayınız.

1) Bir çikolata dükkânında sadece bitter ve beyaz çikolata vardır. Aynı büyüklüğe sahip çikolatalardan beyaz çikolataların sayısı, bitter çikolataların sayısından 146 adet daha azdır. Beyaz çikolataların sayısı 362 olduğuna göre, çikolata dükkânında toplam kaç adet bitter ve beyaz çikolata vardır?

2) Bir sınıftaki kız öğrencilerin sayısı erkek öğrencilerin sayısının 4 katıdır. Kız öğrencilerin sayısı, erkek öğrencilerin sayısından 21 fazla olduğuna göre sınıfta toplam kaç öğrenci olduğunu bulunuz.

3) Bir kırtasiye sahibi 960 adet balonu 240 liraya almıştır. Balonları her pakette 8 balon olacak şekilde paketlere yerleştirmiş ve balonların hepsini satmıştır. Bir paket balonu 4 liraya sattığına göre kırtasiye sahibi kaç lira kâr elde etmiştir?



4) Kinyas ve Kayra bir torbadaki 480 tane bilyeyi paylaşacaklardır. Kayra, Kinyas'dan 82 tane daha az aldığına göre, her birine düşen bilye sayısını bulunuz.

5) Bir mağazada, şekilde verilen uyku tulumlarının toplam fiyatı ile çadırın fiyatı birbirine eşittir.



a) Şekildeki çadırın ve uyku tulumlarının toplam fiyatı 416 lira olduğuna göre, bir çadırın ve bir uyku tulumunun fiyatı kaçar liradır?

Çadır: …….

Uyku Tulumu: …….

b) Kamp malzemesi almaya gelen bir müşteri, yukarıdaki bir çadırı ve birkaç uyku tulumunu almıştır. Müşteri aldığı çadır ve uyku tulumları için 312 lira ödediğine göre, kaç tane uyku tulumu almıştır?

C. VIEWS ABOUT PROBLEM-SOLVING METHOD QUESTIONNAIRE

AD-SOYAD:

Sevgili öğrenciler;

Bu formun amacı problem çözme metodu derslerimiz hakkında görüşleriniz almaktır. Sizin görüşleriniz bu metodu geliştirmek amacıyla kullanılacaktır. Cevaplarınız notlandırma amacıyla kullanılmayacaktır. Bu yüzden gerçek görüşlerinizi detaylı bir şekilde belirtiniz.

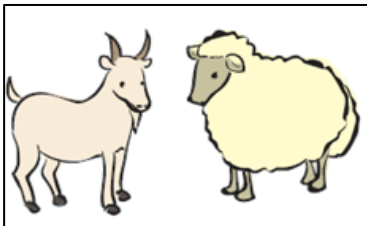
Çalışmaya katkılarınızdan dolayı teşekkür ederim.

1) Matematik denince aklına neler geliyor? Detaylı açıklayınız.

2) Matematik problemi denince aklına neler geliyor? Detaylı açıklayınız.

3) Problem çözme metodu derslerinde çözdüğünüz problemlerle ilgili görüşleriniz nelerdir? Detaylı bir şekilde açıklayınız.

4) Aşağıda verilen yarı yapılandırılmış (ill-structured) problemleri çözerken herhangi bir zorlukla karşılaştınız mı? Cevabınız evetse, nasıl zorluklar yaşadınız? Cevabınız hayırsa sebepleri nelerdir? Açıklayınız.



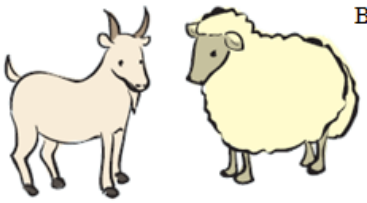
Bir çiftlikte belirli bir miktarda keçi ve koyun vardır. Çiftlikteki koyunların sayısı, keçilerin sayısından fazladır.

a) Koyunların sayısı ve koyunların keçilerden ne kadar fazla olduğu bilindiğine göre, çiftlikte kaç tane hayvan olduğunu hangi yöntem veya yöntemlerle bulabiliriz?

b) Çiftlikteki keçi ve koyunların sayısını eşit hale getirmek için hangi yöntem veya yöntemleri kullanabiliriz?

c) Çiftlikteki keçiler her gün ortalama aynı miktarda süt vermektedir. Bir keçiden elde edilen süt miktarı bilindiğine göre, bir haftada elde edilen süt miktarını hangi yöntem veya yöntemlerle bulabiliriz?

5) Aşağıda verilen iyi yapılandırılmış (well-structured) problemleri çözerken herhangi bir zorlukla karşılaştınız mı? Cevabınız evetse, nasıl zorluklar yaşadınız? Cevabınız hayırsa sebepleri nelerdir? Açıklayınız.



Bir çiftlikte belirli bir miktarda keçi ve koyun vardır. Çiftlikteki koyunların sayısı, keçilerin sayısından 124 fazladır.

a) Koyunların sayısı 568 olduğuna göre, çiftlikte toplam kaç tane hayvan olduğunu bulunuz.

b) Çiftlikteki keçi ve koyunların sayısını eşit hale getirmek için kaç tane koyun veya keçi gerektiğini bulunuz.

c) Çiftlikteki keçilerin her biri günde ortalama 3 litre süt vermektedir. Buna göre, çiftlikteki keçilerin tamamından bir haftada elde edilen süt miktarının kaç litre olduğunu bulunuz.

6) İyi yapılandırılmış problemleri çözmeden önce yarı yapılandırılmış problem biçimlerini çözmek size kolaylık sağladı mı? Cevabınız evetse, nasıl kolaylıklar sağladı? Cevabınız hayırsa sebepleri nelerdir? Açıklayınız.

7) Yarı yapılandırılmış problemlerin çözüm metodunun size faydalı olduğunu düşünüyor musunuz? Cevabınız evetse hangi açılardan size fayda sağladı? Cevabınız hayırsa sebepleri nelerdir? Açıklayınız.

8) Problem çözme metodunun sizde olumlu etkiler bıraktığını düşünüyor musunuz? Cevabınız evetse metodun olumlu etkileri nelerdir? Cevabınız hayırsa sebepleri nelerdir? Açıklayınız.

9) Bunların dışında problem çözme metodu dersleri ile ilgili söylemek istedikleriniz nelerdir?

D. FOCUSED HOLISTIC SCORING POINT SCALE FOR ISPST

Score	Explanation
0	These papers have one of the following characteristics: ❖ They are blank. ❖ The students just copied the given in the problem. There is no work for the planning of the solution. ❖ There is work but no apparent understanding of the problem. ❖ The students gave a number to the unknown in the problem and solved the problem using with these numbers that were not given in the problem. It shows that no understanding of the problem.
1	These papers have one of the following characteristics: ❖ There is a start toward finding the plan beyond just copying the given in problem that reflects few understandings, but the approach used would not have led to a correct plan. ❖ There is a start with an inappropriate plan that reflects few understandings of the problem. ❖ An inappropriate plan is started but not carried out, and there is no evidence that the student turned to another plan. It appears that the students tried one approach that did not work and then gave up. It also shows that few understanding of the problem.
2	These papers have one of the following characteristics: ❖ The students used an inappropriate plan, but the work showed some understanding of the problem. ❖ The students used an inappropriate plan to give the solution way part of the problem, but student did not carry out the plan far enough to give other part of the problem. However, the work showed some understanding of the problem. ❖ The students started with a partially correct plan based on part of the problem being interpreted correctly, but it was not carried out far enough to reach a solution way. It also shows that partial understanding of the problem. ❖ The students gave a number all the given in the problem and did not explain their plan for solution. The students solved the problem with the

	numbers they gave to the given in problem rather than focusing on planning a solution strategy. ❖ There is some evidence that appropriate solution strategies were selected. However, the beginning of the strategies is not completely clear.
3	These papers have one of the following characteristics: ❖ The student has planned a solution strategy that could have led to the correct solution, but he or she misunderstood part of the problem or ignored a condition in the problem. It reflects significant understanding of the problem. ❖ Appropriate solution strategies were properly planned, but students did not label or specify what they found. ❖ The students gave a number all the given in the problem and explain their plan for solution using with number they gave to the given in problem. ❖ The student has planned an appropriate solution strategy and used the correct plan part of the problem. However, the student selected inappropriate plan or did not carry out far enough to find the other parts of the problem because of the ignorance a condition in the problem.
4	These papers have one of the following characteristics: ❖ Appropriate plan was given in terms of the given in the problem and students explained their plan of the solution strategy correctly. ❖ Appropriate plan was visualized in terms of the given in the problem. ❖ Appropriate plan was given in terms of formulate the given in the problem.

E. FOCUSED HOLISTIC SCORING POINT SCALE FOR WSPST

Each question of WSPST was rated over 4 points and thus the highest score that could be obtained from the test was 24. As suggested by Charles, Lester and O'Daffer (1987), focused holistic scoring was used while calculating the mathematical problem solving performance of students in solving well-structured problems. In focused holistic scoring, student's entire solution of each well-structured problem scored by thinking processes involved in solving problem. A template for focused holistic scoring was seen in table.

Score	Explanation
0	These papers have one of the following characteristics: ❖ They are blank. ❖ The data in the problem may be simply recopied, but nothing is done with the data or there is work but no apparent understanding of the problem. ❖ There is an incorrect answer, and no other work is shown.
1	These papers have one of the following characteristics: ❖ There is a start toward finding the solution beyond just copying data that reflects some understanding, but the approach used would not have led to a correct solution. ❖ There is a start with an inappropriate strategy that reflects some understanding, but … a) the student implemented this inappropriate strategy incorrectly. b) the student's answer was not labeled or was labeled incorrectly. ❖ An inappropriate strategy is started but not carried out, and there is no evidence that the student turned to another strategy. It appears that the students tried one approach that did not work and then gave up. It also shows that some understanding of the problem. ❖ The student tried to reach a subgoal for using given in the problem but never did. It shows that some understanding of the problem.
2	These papers have one of the following characteristics: ❖ The students used an inappropriate strategy and got an incorrect answer, but the work showed some understanding of the problem. ❖ The students used an inappropriate strategy and gave the answer part of

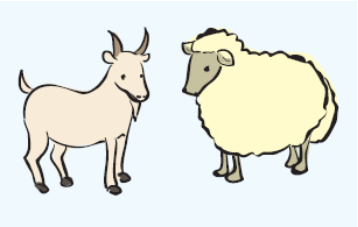
	the problem, but student did not carry out far enough to find other part of the problem. However, the work showed some understanding of the problem. ❖ An appropriate strategy was used, but … a) it was not carried out far enough to reach a solution. b) it was implemented incorrectly and thus led to no answer or an incorrect answer. c) it was implemented incorrectly due to find incorrect answer for the previous item of the problem if the subproblems or items are interrelated. d) it was not carried out far enough to reach a solution and the student made a copying or computational error in implementing the strategy. ❖ The student successfully reached a subgoal but went no further. ❖ The correct answer is shown, but … a) the work is not understandable. b) no work is shown.
3	These papers have one of the following characteristics: ❖ The student has made a plan that could have led to the correct solution, but he or she was not implemented his or her plan for solving the problem. ❖ The student has implemented a solution strategy that could have led to the correct solution, but he or she misunderstood part of the problem or ignored a condition in the problem. ❖ The student has implemented a solution strategy and gave the correct answer part of the problem. However, the student answered incorrectly or did not carry out far enough to find the other parts of the problem because of the ignorance a condition in the problem. ❖ Appropriate solution strategies were properly applied, but … a) the student answered the problem incorrectly for no apparent reason. b) the correct numerical part of the answer was given, and the answer was not labeled or was labeled incorrectly. c) he or she misunderstood part of the problem and got an incorrect answer. d) no answer is given. ❖ The correct answer is given, and there is some evidence that appropriate solution strategies were selected. However, the implementation of the strategies is not completely clear.
4	These papers have one of the following characteristics:

	❖ The student made an error in carrying out an appropriate solution strategy. However, this error does not reflect misunderstanding of either the problem or how to implement the strategy, but rather it seems to be a copying or computational error. ❖ Appropriate strategies were selected and implemented. a) the correct answer was given in terms of the data in the problem and student labeled calculation correctly. b) the correct answer was given in terms of the data in the problem and student explained or visualized his or her plan of the solution strategy. c) the correct answer was given in terms of the data in the problem and student control the solution corrects or not.

F. PROBLEMS FOR PROBLEM-SOLVING METHOD INSTRUCTION (PSI)

ÇALIŞMA KAĞIDI 1

1) Bir çiftlikte belirli bir miktar keçi ve koyun vardır. Çiftlikteki koyunların sayısı, keçilerin sayısından fazladır.

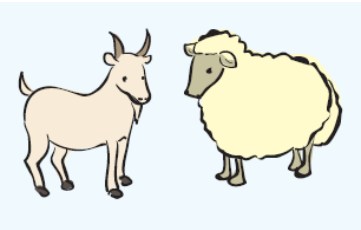


a) Koyunların sayısı ve koyunların keçilerden ne kadar fazla olduğu bilindiğine göre, çiftlikte toplam kaç tane hayvan olduğunu hangi yöntem veya yöntemlerle bulabiliriz?

b) Çiftlikteki keçi ve koyunların sayısını eşit hale getirmek için hangi yöntem veya yöntemleri kullanabiliriz?

c) Çiftlikteki keçiler her gün ortalama aynı miktarda süt vermektedir. Bir keçiden elde edilen süt miktarı bilindiğine göre, bir haftada elde edilen süt miktarını hangi yöntem veya yöntemlerle bulabiliriz?

2) Bir çiftlikte belirli bir miktar keçi ve koyun vardır. Çiftlikteki koyunların sayısı, keçilerin sayısından 124 fazladır. Koyunların sayısı 568 olduğuna göre, çiftlikte toplam kaç tane hayvan olduğunu bulunuz.



a) Çiftlikteki keçi ve koyunların sayısını eşit hale getirmek için hangi yöntem veya yöntemleri kullanabiliriz?

b) Çiftlikteki keçi ve koyunların sayısını eşit hale getirmek için hangi yöntem veya yöntemleri kullanabiliriz?

c) Çiftlikteki keçilerin her biri günde ortalama 3 litre süt vermektedir. Buna göre, çiftlikteki keçilerin tamamından bir haftada elde edilen süt miktarının kaç litre olduğunu bulunuz.

ÇALIŞMA KAĞIDI 2

1)



Bir kütüphanede kutular raflara şekildeki gibi yerleştirilmiştir. Kutuların her birinde aynı sayıda dergi bulunduğuna göre,

a) 2.rafta bulunan kutuların içindeki toplam dergi sayısı bilindiğine göre, 1.rafta bulunan kutuların içindeki toplam dergi sayısını bulmak için hangi yöntem veya yöntemleri kullanabiliriz?

b)2.rafta bulunan dergi sayısının, 1.raftakinden ne kadar fazla olduğunu hangi yöntem veya yöntemlerle bulabiliriz?

c)1.rafa, 1 kutu dergi daha eklendiğinde, 2.raftaki dergi sayısı 1.raftakinin kaç katı olur? Kullandığınız yöntem veya yöntemleri detaylı bir şekilde belirtiniz.

2)



Bir kütüphanede kutular raflara şekildeki gibi yerleştirilmiştir. Kutuların her birinde aynı sayıda dergi bulunduğuna göre,

a) 2.rafta bulunan kutuların içinde toplam 132 adet dergi olduğuna göre, 1.rafta bulunan kutuların içinde toplam kaç adet dergi olduğunu bulunuz.

b) 2.rafta bulunan dergi sayısının, 1.raftaki dergi sayısından ne kadar fazla olduğunu bulunuz.

3) Bir organik yumurta çiftliğinde günlük belirli miktarda yumurta elde edilmektedir. Yumurtalar, yumurta kolilerine şekildeki gibi yerleştirildiğinde hiç yumurta artmamaktadır. Bir günde elde edilen toplam yumurta sayısı ve her bir kolinin satış fiyatı bilindiğine göre, çiftliğin günlük ne kadar kazandığını hangi yöntem veya yöntemlerle bulabiliriz?



4) Bir organik yumurta çiftliğinde günlük 720 adet yumurta elde edilmektedir. Yumurtalar, yumurta kolilerine şekildeki gibi yerleştirildiğinde hiç yumurta artmamaktadır. Yumurta kolisinin tanesi 9 liradan satıldığına göre, çiftliğin günlük ne kadar kazanç sağladığını bulunuz.



ÇALIŞMA KAĞIDI 3

1) Bir okulda "Çevreyi Koruyalım" kampanyasında, 5.sınıflar arası atık pet şişe toplama yarışması düzenlenmiştir.



a) 5-A sınıfının topladığı pet şişelerin adedi, 5-B sınıfının topladığı pet şişe adedinden belirli bir miktar azdır. İki sınıfta biriktirilen toplam pet şişe adedi ve 5-A'nın 5-B'den ne kadar az pet şişe topladığı bilindiğine göre, sınıfların kaçar adet pet şişe topladığını hangi yöntem veya yöntemlerle bulabiliriz?

b) 5/C ve 5/D sınıfları eşit miktarlarda pet şişe toplamıştır. Bu iki sınıfın topladığı pet şişelerin tamamı, 5/A'nın topladığı toplam pet şişelerin 3 katı kadar ya da 5/B'nın topladığı toplam pet şişelerin 2 katı kadardır. Buna göre, 5/C ve 5/D'nin kaçar adet pet şişe topladığını hangi yöntem veya yöntemlerle bulabiliriz?

2) Bir okulda "Çevreyi koruyalım" kampanyasında, 5.sınıflar arası atık pet şişe toplama yarışması düzenlenmiştir.



a) 5-A sınıfının topladığı pet şişelerin adedi, 5-B sınıfının topladığı pet şişelerden 32 adet azdır. Bu iki sınıfta toplanan toplam pet şişe sayısı 1028 olduğuna göre, bu sınıfların kaçar adet pet şişe topladığını bulunuz.

b) 5/C ve 5/D sınıfları eşit miktarlarda pet şişe toplamıştır. Bu iki sınıfın topladığı pet şişelerin tamamı, 5/B'nin topladığı toplam şişelerin 5 katından 8 eksik ya da 5/A'nın topladığı toplam şişelerin 5 katından 152 adet fazladır. Buna göre, 5/C ve 5/D'nin kaçar adet pet şişe topladığını bulunuz.

3) Bir müşteri, yanda verilen masa ve sandalyelerden almak istemektedir. Şekildeki masanın fiyatı, sandalyelerin toplam fiyatına eşittir.



a) Masa ve sandalyelerin toplam fiyatı belli olduğuna göre, masa ve bir tane sandalyenin fiyatının kaçar lira olduğunu hangi yöntem veya yöntemlerle elde edebiliriz?

b) Müşterinin belirli bir miktar parası vardır. Parasının tamamıyla şekildeki masayı ve birkaç sandalyeyi alabilmektedir. Müşterinin sahip olduğu para miktarı bilindiğine göre, masanın yanında kaç sandalye aldığını hangi yöntem veya yöntemlerle bulabiliriz?

4) Bir müşteri, yanda verilen masa, sandalye takımını almak istemektedir. Şekildeki masanın fiyatı, sandalyelerin toplam fiyatına eşittir.



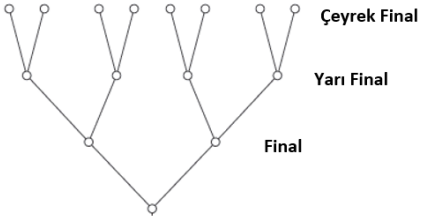
a) Masa ve sandalyelerin toplam fiyatı 996 lira olduğuna göre, masa ve bir tane sandalyenin fiyatının kaçar lira olduğunu bulunuz.

Masa:……. **Sandalye:……..**

b) Bir müşterinin 830 lira parası vardır. Müşteri sahip olduğu paranın tamamıyla şekildeki masayı ve birkaç sandalyeyi alabildiğine göre, masanın yanında kaç sandalye aldığını bulunuz.

ÇALIŞMA KAĞIDI 4

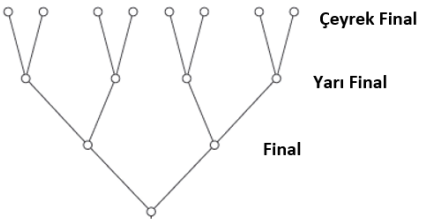
1) Bir golf turnuvasında, her etapta oyuncular eşit sayıda vuruş yapmaktadır. Karşılaşmada kaybeden oyuncular turnuvadan çekilmektedir. Turnuva boyunca yapılan toplam vuruş sayısı belli olduğuna göre,



a) Karşılıklı bir maçta bir oyuncunun yaptığı vuruş sayısını hangi yöntem veya yöntemlerle bulabiliriz?

b) Final maçını kazanan oyuncunun toplamda kaç vuruş yaptığını hangi yöntem veya yöntemlerle bulabiliriz?

2) Bir golf turnuvasında, her etapta oyuncular eşit sayıda vuruş yapmaktadır. Karşılaşmada kaybeden oyuncular turnuvadan çekilmektedir. Turnuva boyunca toplamda 70 vuruş yapıldığına göre,



a) Karşılıklı bir maçta bir oyuncunun yaptığı vuruş sayısını bulunuz.

b) Final maçını kazanan oyuncunun toplamda kaç vuruş yaptığını bulunuz.

3) Deniz, aylık belirli bir miktar taksitle araba satın almıştır ve borcunu bir yılda bitirecektir. Deniz, taksitlerinin birkaçını ödemiştir. Aylık taksit miktarı ve borcun ne kadarının ödendiği bilindiğine göre, Deniz'in kaç ay daha taksit ödemesi gerektiğini hangi yöntem veya yöntemlerle bulabiliriz?

4) Deniz, aylık 3 500 lira taksitle araba almıştır ve borcunu 3 yılda ödeyecektir. Deniz, borcunun 52 500 liralık kısmını ödemiştir. Buna göre Deniz'in kaç ay daha taksit ödemesi gerektiğini bulunuz.

ÇALIŞMA KAĞIDI 5

1) Bir hayvan barınağında sadece kedi ve köpekler yaşamaktadır. Kedi ve köpeklerin sayısı birbirine eşittir.

a) Bir süre sonra barınaktaki kedilerin yarısı sahiplenilmiştir. Kötü hava koşullarından dolayı ise var olan köpek sayısı kadar daha barınağa köpek getirilmiştir. Başlangıçtaki toplam kedi ve köpek sayısı bilindiğine göre, son durumda barınakta bulunan hayvan sayısını hangi yöntem veya yöntemlerle bulabiliriz?

b) Bir kedi ve bir köpeğin günlük tükettiği mama miktarları bilindiğine göre, başlangıçta barınakta bulunan kedi ve köpeklerin bir günde tükettiği toplam mama miktarını hangi yöntem veya yöntemlerle bulabiliriz?

c) Son durumda barınakta yaşayan kedi ve köpeklerin bir günde tükettiği toplam mama miktarı ile ilk durumda tüketilen toplam mama miktarı arasındaki değişimi hangi yöntem veya yöntemleri kullanarak bulabiliriz?

2) Bir hayvan barınağında sadece kedi ve köpekler yaşamaktadır. Kedi ve köpeklerin sayısı birbirine eşittir.

a) Bir süre sonra barınaktaki kedilerin yarısı sahiplenilmiştir. Kötü hava koşullarından dolayı var olan köpek sayısı kadar daha barınağa köpek getirilmiştir. Başlangıçta toplam 120 tane kedi ve köpek olduğuna göre, son durumda barınakta bulunan hayvan sayısını bulunuz.

b) Bir kedi günde ortalama 60 gram, bir köpek ise günlük ortalama 240 gram mama tükettiğine göre, başlangıçta barınakta bulunan kedi ve köpeklerin bir günde tükettiği toplam mama miktarını bulunuz.

c) Son durumda barınakta yaşayan kedi ve köpeklerin bir günde tükettiği toplam mama miktarı ile ilk durumda tüketilen toplam mama miktarı arasındaki farkı bulunuz.

3) Şekildeki gömleklerin toplam fiyatı ile ayakkabının fiyatı birbirine eşittir. Ayakkabının fiyatı, gömleğin fiyatından bir miktar fazladır. Ayakkabının, gömlekten ne kadar fazla olduğu bilindiğine göre, bir ayakkabı ve bir gömlek alan müşterinin kaç lira ödeyeceğini hangi yöntem veya yöntemlerle bulabiliriz?



4) Şekildeki gömleklerin toplam fiyatı ile ayakkabın fiyatı birbirine eşittir. Ayakkabının fiyatı, bir gömleğin fiyatından 84 lira fazladır. Buna göre, bir ayakkabı ve bir gömlek alan müşterinin kaç lira ödeyeceğini bulunuz.



ÇALIŞMA KAĞIDI 6



1) Bir fırıncının hafta içi sattığı ekmek miktarı ile ilgili olan aşağıdaki soruları cevaplayınız.

a) Fırıncı pazartesi günü belirli bir miktar ekmek satmıştır. Salı günü, pazartesi gününden daha az ekmek satmıştır. Salı günü satılan ekmek sayısı ve salı günü pazartesi gününden ne kadar az ekmek satıldığı bilindiğine göre, pazartesi günü kaç tane ekmek satıldığını hangi yöntem veya yöntemlerle bulabiliriz?

b) Fırıncının hafta içi toplam kaç adet ekmek sattığı bilinmektedir. Çarşamba, perşembe ve cuma günleri eşit miktarda ekmek satıldığına göre, bu üç günün her birinde fırıncının kaç adet ekmek sattığını hangi yöntem veya yöntemlerle bulabiliriz?



2) Bir fırıncının hafta içi sattığı ekmek miktarı ile ilgili olan aşağıdaki soruları cevaplayınız.

a) Fırıncı salı günü …… adet ekmek satmıştır. Salı günü, pazartesi gününden …….. adet daha az ekmek satmıştır. Buna göre, pazartesi günü fırıncının kaç adet ekmek sattığını bulunuz.

b) Bu fırın hafta içi toplam …… adet ekmek satmıştır. Çarşamba, perşembe ve cuma günleri eşit miktarda ekmek satıldığına göre, bu üç günün her birinde fırının kaç adet ekmek sattığını bulunuz.

3) Şekildeki kalemlerin toplam fiyatı ile kalem kutusunun fiyatı birbirine eşittir. Bir kalemin fiyatı, kalem kutusunun fiyatından bir miktar azdır. Bir kalemin fiyatının, kalem kutusunun fiyatından ne kadar az olduğu bilindiğine göre, bir kalem kutusu ve bir kalem alan kişinin kaç lira ödeyeceğini hangi yöntem veya yöntemlerle bulabiliriz? Cevabınızı detaylı bir şekilde açıklayınız.



4) Şekildeki kalemlerin toplam fiyatı ile kalem kutusunun fiyatı birbirine eşittir. Bir kalemin fiyatı, kalem kutusunun fiyatından …… lira azdır. Buna göre, bir kalem kutusu ve bir kalem alan kişinin kaç lira ödeyeceğini bulunuz.

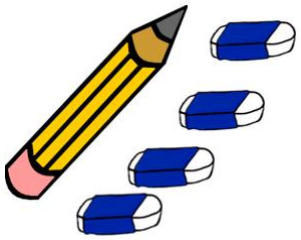


ÇALIŞMA KAĞIDI 7

1) Aren'in kırmızı, mavi ve sarı renkte belirli bir miktar legosu vardır. Aren'in mavi legoları kırmızı legolarından bir miktar fazladır, ayrıca sarı legoları da kırmızı legolarından bir miktar fazladır. Aren'in toplam lego sayısı, mavilerin kırmızılardan ne kadar fazla olduğu ve sarıların kırmızılardan ne kadar fazla olduğu bilindiğine göre, Aren'in her renkten kaç tane legosu olduğunu hangi yöntem veya yöntemlerle bulabiliriz? Cevabınızı detaylı bir şekilde açıklayınız.

2) Şimdi yukarıda verilen probleme sayılar vererek baştan oluşturup, boş kısma yazınız. Oluşturduğunuz problemi detaylı bir şekilde çözünüz.

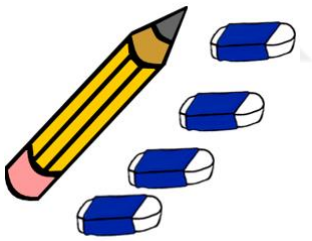
3) Bir kırtasiyede şekilde verilen bir kalem ile silgilerin toplam fiyatı birbirine eşittir.



a) Şekildeki kalem, silgi setinin toplam fiyatı bilindiğine göre, bir kalem ile bir silginin fiyatını hangi yöntem veya yöntemlerle bulabiliriz?

b) Bir müşteri, 1 tane kalem ve birkaç tane silgi almıştır. Müşterinin aldığı kalem ve silgiler için ödediği para miktarı bilindiğine göre, kaç tane silgi aldığını hangi yöntem veya yöntemleri kullanarak bulabiliriz?

4) Bir kırtasiyede şekilde verilen kalem ile silgilerin toplam fiyatı birbirine eşittir.



a) Şekildeki kalem, silgi setinin toplam fiyatı 16 lira olduğuna göre, bir kalem ile bir silginin fiyatını bulunuz.

b) Bir müşteri, 1 tane kalem ve birkaç tane silgi almıştır. Müşteri aldığı kalem ve silgiler için 24 lira ödediğine göre, kaç tane silgi aldığını bulunuz.

G. CLASSROOM OBSERVATION CHECKLIST

Sayın Araştırmacı,

5.sınıflarda problem çözme dersini gözlemlemek için bulunmaktasınız. Derslerde problem çözme metodunun düzgün bir şekilde kullanıldığından emin olmak için işlenen derslerle ilgili olarak aşağıdaki tabloyu doldurunuz. Tabloyu doldururken sorulara vereceğiniz ve uygulamanın sınıf içerisinde nasıl yapıldığını ifade edecek olan cevabınızı "birden yediye kadar", derecelendirerek veya "yapılmadı" şeklinde ifade etmeniz gerekmektedir. Lütfen tüm kriterler için cevaplarınızı sağ taraftaki sütunda ilgili seçenekten 1 tanesini (X) şeklinde işaretleyerek belirtiniz. Bu gözlem formu, Gökhan Serin'in Probleme Dayalı Öğrenme Öğretiminin 7.Sınıf Öğrencilerin Fen Başarısına, Fene Karşı Tutumuna ve Bilimsel Süreç Becerilerine Etkisi isimli tezinden uyarlanmıştır.

Gözlem Listesi								Yapılmadı
	1	2	3	4	5	6	7	
1. Dersin işlenişi sırasında kullanılacak problem kâğıtları öğrencilere çevrimiçi gönderildi.								
2. Problemi çözme yöntemleri öğrencilere detaylı bir şekilde açıklandı.								
3. Problemi çözmeleri için öğrencilere vakit verildi.								
4. Öğretmen bir öğrenciye problemi okutarak anlaşılmayan bir yer olup olmadığını sordu.								
5. Öğretmen problemde ne istendiğini sordu.								

6. Problemde anlaşılmayan noktalar sınıfça tartışılarak açıklığa kavuşturuldu.								
7. Problem çözme aşamasında, problemi çözen öğrencilere çözümlerinden emin olup olmadıklarını emin değilseler tekrar kontrol etmeleri için uyarıda bulundu.								
8. Problem üzerinde bireysel şekilde çalışma süresi bittiğinde öğretmen problem çözme sürecini bittiğini söyledi.								
9. Problemin sınıfça tartışılma aşamasında söz isteyen her öğrenciye söz hakkı verildi.								
10. Problemi çözmek için farklı stratejiler geliştiren öğrencilerin cevapları öğretmen tarafından ekrana yazıldı.								
11. Farklı çözüm yolları, problem stratejileri sınıfça tartışıldı.								
12. Öğrenciler kendi çözüm yollarını anlatırken, diğer arkadaşları onları dinledi.								
13. Öğrenciler birbirlerinin çözüm yollarına saygı gösterdiler.								
14. Öğretmen öğrencilere eşit davrandı.								
15. Öğretmen yönlendirici ve tartışma açıcı şekilde davrandı.								
16. Öğretmen derse katılımı artırmak için öğrencilere ayrı ayrı soru sordu.								
17.Öğretmen söz alıp konuşmak isteyenlere olanak tanıdı.								
18. Öğretmen öğrencilere düşündürücü sorular sordu.								
19. Öğretmen dersi tartışma merkezli olarak yürüttü.								

Sınıf: ……
Tarih: …….
Ders süresi: …….
Değerlendiren: ……

H. ETHICAL APPROVAL

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
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MIDDLE EAST TECHNICAL UNIVERSITY

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13 KASIM 2020

Konu: Değerlendirme Sonucu

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi: İnsan Araştırmaları Etik Kurulu Başvurusu

Sayın Safure BULUT

Danışmanlığını yaptığınız Özge KANAR'ın "***Problem Çözme Metodunun 5.Sınıf Öğrencilerini Problem Çözme Performansına Etkisi ve Öğrencilerin Problem Çözme Metodu Hakkındaki Görüşleri***" araştırması İnsan Araştırmaları Etik Kurulu tarafından uygun görülmüş ve **340-ODTU-2020** protokol numarası ile onaylanmıştır.

Saygılarımızla bilgilerinize sunarız.

Prof. Dr. Mine MISIRLISOY
İAEK Başkanı

İ. PERMISSION OBTAINED FROM MINISTRY OF EDUCATION

BÖ

T.C.
NİĞDE VALİLİĞİ
İl Millî Eğitim Müdürlüğü

Sayı : E-61900286-605.01-20162982 04.02.2021
Konu : Araştırma İzni
(Özge KANAR)

DAĞITIM YERLERİNE

İlgi : a) Milli Eğitim Bakanlığına Bağlı Okul Ve Kurumlarda Yapılacak Araştırma Ve Araştırma Desteğine Yönelik İzin Ve Uygulama Yönergesi.
b) Ortadoğu Teknik Üniversitesi Öğrenci İşleri Daire Başkanlığının 26/01/2021 tarihli ve 269 sayılı yazısı.
c) Valilik Makamının 03.02.2021 tarih ve 20114361 sayılı Olurları.

İlgi (b) yazı gereği Müdürlüğümüz Araştırma Değerlendirme Komisyonu tarafından yapılan değerlendirme sonucunda, Ortadoğu Teknik Üniversitesi Matematik ve Fen Bilimleri Eğitimi EABD yüksek lisans programı öğrencisi Özge KANAR' ın, İlimiz Merkez Niğde Özel ODTÜ Geliştirme Vakfı Ortaokulunda Problem Çözme Metodunun 5. Sınıf Öğrencilerinin Problem Çözme Performansına Etkisi ve Öğrencilerin Problem Çözme Metodu Hakkındaki Görüşleri" konulu tez çalışmasını uygulama yapmasına ilişkin, Valilik Makamından alınan ilgi (c) Olur, yazımız ekinde sunulmuştur.

Bilgilerinizi ve gereğini arz/rica ederim.

Halil İbrahim YAŞAR
Milli Eğitim Müdürü

Ek:
1-Valilik Oluru (1 sayfa)
2-Araştırma Değerlendirme Komisyon Görüşü (3 sayfa)
3-Başvuru Taahhütnamesi (2 sayfa)

Dağıtım:
- Ortadoğu Teknik Üniversitesi Rektörlüğü
Öğrenci İşleri Daire Başkanlığına
- Niğde Özel ODTÜ Geliştirme Vakfı
Ortaokulu Müdürlüğüne

Bu evrakın 5070 Sayılı Kanun Gereğince E-İMZA ile imzalandığı tasdik olunur 4...02...2021
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J. PARENT APPROVAL FORM

Sevgili Veliler,

Bu çalışma, Orta Doğu Teknik Üniversitesi yüksek lisans öğrencisi Özge Kanar tarafından yürütülmektedir.

Bu çalışmanın amacı nedir?

Araştırmanın amacı, problem çözme metodunu derslerinin 5.sınıf problem çözme performansına etkisini üç zaman aralığında ölçmektir.

Çocuğunuzun katılımcı olarak ne yapmasını istiyoruz?

Bu amaç doğrultusunda, çocuğunuza araştırmanın başında, sonunda ve kalıcılığı test etmek için program bitiminden bir süre sonra olmak üzere üç farklı zaman aralığında problem çözme performansını ölçecek testler uygulanacaktır. Her zaman aralığında iki adet 5'er tane problem içeren testler uygulanıp detaylı bir şekilde çözmeleri beklenmektedir. Ayrıca, 6 hafta boyunca haftada bir ders saati olmak koşuluyla problem çözme metodu çalışması uygulanacaktır. Çalışma sonunda, problem çözme metodu dersleri hakkındaki görüşleri de alınacaktır. Ayrıca, birkaç öğrenci ile birebir görüşmeler yapılacaktır. Sizden çocuğunuzun katılımcı olmasıyla ilgili izin istediğimiz gibi, çalışmaya başlamadan çocuğunuzdan da sözlü ve yazılı olarak katılımıyla ilgili rızası mutlaka alınacak.

Çocuğunuzdan alınan bilgiler ne amaçla ve nasıl kullanılacak?

Çocuğunuzdan alacağımız cevaplar tamamen gizli tutulacak ve sadece araştırmacılar tarafından değerlendirilecektir. Elde edilecek bilgiler sadece bilimsel amaçla kullanılacak, çocuğunuzun ya da sizin ismi ve kimlik bilgileriniz, hiçbir şekilde kimseyle paylaşılmayacaktır.

Çocuğunuz ya da siz çalışmayı yarıda kesmek isterseniz ne yapmalısınız?

Çalışma, genel olarak kişisel rahatsızlık verecek sorular ve durumlar içermemektedir. Yine de, katılım sırasında sorulan sorulardan ya da herhangi bir uygulama ile ilgili başka bir nedenden ötürü çocuğunuz kendisini rahatsız hissettiğini belirtirse, ya da kendi belirtmese de araştırmacı çocuğun rahatsız olduğunu öngörürse, çalışmaya sorular tamamlanmadan ve derhal son verilecektir. Şayet siz çocuğunuzun rahatsız olduğunu hissederseniz, böyle bir durumda çalışmadan sorumlu kişiye çocuğunuzun çalışmadan ayrılmasını istediğinizi söylemeniz yeterli olacaktır.

Bu çalışmayla ilgili daha fazla bilgi almak isterseniz:

Çalışmaya katılımınızın sonrasında, bu çalışmayla ilgili sorularınız yazılı biçimde cevaplandırılacaktır. Çalışmayla ilgili sorularınızı araştırmacıya adresinden iletebilirsiniz. Bu çalışmaya katılımınız için şimdiden teşekkür ederiz.

Ön sayfadaki bilgileri okudum ve çocuğumun bu çalışmada yer almasını onaylıyorum (Lütfen alttaki iki seçenekten birini işaretleyiniz).

Evet onaylıyorum___ ***Hayır, onaylamıyorum___***

Annenin adı-soyadı: _____ Bugünün Tarihi:_____

Çocuğun adı soyadı ve doğum tarihi:_____

(Formu doldurup imzaladıktan sonra araştırmacıya ulaştırınız).