

A Comparison of Problem-Solving Strategies of Primary School 3rd and 4th-Graders

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Abstract. The aim of the study is to find out the problem-solving strategies used by primary school 3rd and 4th-graders in solving non-routine problems. The basic qualitative research design, one of the qualitative research approaches, was used in the research. The participants of the research consisted of 216 students, 104 of them in the third-grade and 112 of them in the fourth-grade. The "problem-solving test" developed by the researcher was used as a data collection tool. Descriptive analysis method was used in the analysis of the data. When the results of the research were examined, it was discovered that primary school third-graders mostly used making a drawing strategy in solving non-routine problems; guessing and checking and looking for a pattern strategies were the most commonly used strategies after making a drawing strategy. When the problem-solving strategies used by primary school fourth-graders were examined, it was discovered that guessing and checking was the most commonly used strategy and this strategy was followed by the strategy of looking for a pattern and making a drawing. It was concluded that primary school fourth-graders were more likely to use the other problem-solving strategies apart from making a drawing strategy than the third-graders.

Keywords: Mathematics teaching, non-routine problem, routine problem, primary school, problem-solving strategies

1. Introduction

In the century we live in, which is called the information age, the information and the ways of accessing information are of great importance. Progress in the ways of accessing information brings with it various challenges. These difficulties are the problems that we need to solve in order to access information and continue our lives. The solution approach of problems in real-life situations is through mathematical problems (Çekirdekçi & Çilingir, 2021). Problem-solving and strategic thinking are considered to be the most important cognitive activities that will serve a person throughout his/her life in daily and professional environments (Fülop, 2015; Jonassen 2000; Posamentier & Krulwik, 2009). The importance of problem-solving in learning mathematics comes from the belief that mathematics is primarily about reasoning, not memorization. Therefore, problem-solving allows students to improve their understanding and explain the processes used to reach solutions, rather than remembering and applying a set of procedures (Klerein & Hervey, 2019). It is very important and necessary to make a creative effort to solve problems and to develop and use higher level thinking skills (Muir, Beswick & Williamson, 2008; Reys, Lindquist, Lambdin & Smith, 2009).

1.1. Problem Statement

Problem-solving which is one of the first experiences of children at all levels of mathematics starting from kindergarten and preschool classes is one of the key experiences that should be learned at an early age such as examination, questioning, representation, creative thinking, generalization and communication (Haylock & Cockburn, 2014). Problem-solving is a simulated activity of problem situations, providing context and reason for learning mathematics (Wijaya, Van den Heuvel-Panhuizen & Doorman, 2015). Problem-solving, which forms the basis of mathematics, has an important place in mathematics teaching and is an integral component of the mathematics curriculum (Dossey, 2017; National Council of Teachers of Mathematics, 2000). The studies indicate that having problem-solving strategies has an important place in

finding solutions to problems (Jones, 2012; Reys & et al., 2009). Problem-solving strategies are each of the cognitive activity students put forward while solving a problem (Altun, Memnun, & Yazgan, 2007). Problem-solving strategies make the solution of a problem much easier, more organized, more understandable and therefore fun (Posamentier & Krulick, 2009). There is no specific way or method to be used in solving all problems.

1.2. Related Research

Problem-solving is the core component of mathematics education. Thus, in the practice of teaching mathematics, students are helped to solve problems; problem-solving represents a powerful approach to expanding mathematical concepts and skills (Katalin Szabo, Körtesi, Szabo & Neag, 2020). Strategies used to solve problems are methods that can be determined independently of the subject. While preparing a plan to solve the problem, students choose or design a strategy (Van de Walle, Karp, & Bay-Williams, 2014).

When the studies on problem-solving strategies is examined, it is determined that the main strategies are making a systematic list, making a table, guessing and checking, simplifying the problem, acting the situation out, working backwards, looking for a pattern, logical reasoning, making a drawing, adopting a different point of view, making a diagram, writing an equation, elimination the possibilities and using variables (Altun, 2018; Altun, Bintaş, Yazgan & Arslan, 2004; Jones, 2012; Posamentier & Krulick, 2009; Reys & et al., 2014; Van de Walle, Karp & Bay-Williams, 2014).

In the study conducted by Elia, Van den Heuvel-Panhuizen and Kolovou (2009), students in the 4th-grade (9-10 years old) with high mathematics scores tend to prefer some strategies to the other, even with different results in terms of choosing the strategies to be used to solve non-routine problems. Students often used guessing and checking with a high success rate. In Yazgan's (2016) study, in which fourth graders grad the order of importance and distinctiveness of each strategy in terms of problem-solving success in non-routine problems, it was found that the strategies explained 84% of the problem-solving success, and that the order of importance of the strategies used was model searching, working backwards, making a systematic list, making a drawing, guessing and checking, and simplification. Yazgan (2007), in her study, stated that as a result of teaching 4th and 5th-graders about problem-solving strategy, the strategies of guessing and checking, working backwards, making a drawing and making systematic lists were used easily by the students and also the strategies that the students had the most difficulty in applying were the strategies of looking for a pattern and simplifying the problem.

1.3. Research Objectives

Determining the strategies used by students in problem-solving at primary school level, which is the most important level of education is considered very important to demonstrate that there are different strategies for solving a problem, to reveal which strategies are used frequently at which grade level and which are used less frequently, to give ideas to classroom teachers in terms of creating teaching content for teaching problem-solving strategies, to include problems that require the use of different strategies in student textbooks, to determine the level at which students who will encounter more abstract and algebraic equation problems at secondary school level can use problem-solving strategies at primary school level. This study is aimed to find out the problem-solving strategies used by primary school 3rd and 4th-graders in solving non-routine problems, considering that it will contribute to the specified causes.

For this purpose, the research questions are as follows:

1. What are the problem-solving strategies used by 3rd-grade primary school students?
2. What are the problem-solving strategies used by primary school 4th-grade students?
3. What are the differences between the problem-solving strategies used by 3rd and 4th-grade primary school students?

2. Theoretical Framework

The problem is the situation that arouses the desire to solve the problem, the person wants to do something but cannot immediately predict what to do, the solution is not ready, but the person can solve it using his/her existing knowledge and experience (Altun, 2018; Olkun & Toluk Uçar, 2012; Posamentier & Krulik, 2009; Reys & et al., 2014). Adair (2007), on the other hand, defined the problem literally as "something thrown in front of you". According to Pesen 2020, to ensure that a topic is a problem is to allow students to use their reasoning skills, wonder, question, search for answers and analyze and resolve disputes.

There are two types of problems in primary school mathematics, routine and non-routine (Altun, 2018; Jones, 2012; Reys & et al., 2014; Schloeglmann, 2004). Routine problems are problems in mathematics textbooks and can be solved with four operation skills (Altun, 2018). Unlike routine problems that involve the application of routine calculations, non-routine problems do not have a simple solution. In order to understand the problem situation and solve the problem in non-routine problems, it is necessary to activate creative thinking as well as more than one similar strategy. Therefore, non-routine problems are considered more complex and difficult than routine problems (Dinç Artut & Tarım, 2006; Elia, Van den Heuvel-Panhuizen & Kolovou, 2009; Kolovou, Van den Heuvel-Panhuizen, Bakker, 2009).

The most accepted process for the solutions of routine and non-routine problems is a four-stage process given by Polya (2014) the steps of this process are understanding the problem, devising a plan, carrying out the plan and looking back over the result. Which strategy to choose in planning for the solution in the second step depends on the person who solves the problem (Altun, 2018). Students can come up with different solutions to the same problem with different approaches and strategies according to their own level of understanding and cognition. This is the superiority of problem-solving over producing uniform solutions using traditional rules and symbols (Olkun & Toluk Uçar, 2012).

3. Method

3.1. Research Design

The design of the study, which aims to find out the problem-solving strategies used by primary school 3rd and 4th-graders in solving non-routine problems, is the basic qualitative research design, one of the qualitative research approaches. Qualitative research is an interrogative and interpretive method and effort to understand the form of the problem in its natural environment (Klenke, 2016). Basic qualitative research is concerned with how individuals make sense of their own lives and how they interpret the world and the environment (Merriam & Tisdell, 2016).

3.2. Participant/Respondent

The participants of the research consisted of 216 students, 104 of them in the third-grade and 112 of them in the fourth-grade in two different public primary schools in Ankara, Turkey, in October of the 2021-2022 academic year. The basic understanding in this sampling method is to study situations that meet a predetermined set of criteria. The criteria can be created by the researcher or a pre-prepared criteria list can be used (Yıldırım & Şimşek, 2021). The participants of the research was discovered by using criterion sampling, one of the purposive sampling methods. The fact that they had not received any education about problem-solving strategies before, and that they were at different socio-economic, socio-cultural levels were determined as criteria. Since the research aimed to find out the problem-solving strategies of the students rather than the correct or wrong answers of the students, the same problem-solving test was applied to all students, regardless of grade level.

3.3. Data Collection Tool

The "problem-solving test" developed by the researcher was used as a data collection tool in the research. The "problem-solving test" consisting of 10 questions was created by the researcher by scanning the relevant literature, primary school student textbooks and

workbooks, domestic and foreign sources. The prepared problems are non-routine problems that make it possible to reach the right answer and enable students to use at least two of the problem-solving strategies suitable for primary school level such as making a systematic list, guessing and checking, making a drawing, looking for a pattern, simplifying the problem, working backwards, logical reasoning. According to Davis (1992), seeking expert opinion is one of the ways to determine content validity. Davis analysis was carried out by taking expert opinions from 2 classroom teachers, 1 mathematics teacher and 2 experts in the field to find out the suitability of the questions for the level of the students and which strategies could be solved. Davis (1992) grades expert opinions on the technique as (1) "The item is appropriate", (2) "The item needs some correction", (3) "The item should be seriously reviewed" and (4) "The item is not suitable". In this technique, the content validity index (CVI) of 0.91 was obtained by dividing the number of experts who ticked options (1) and (2) by the total number of experts. If the CVI is above 0.80, it is accepted that the content validity result of the questions in the scale is appropriate (Davis, 1992). In line with the expert opinions, it was discovered that the problems could be solved with different strategies and were suitable for the grade levels. Necessary arrangements in terms of spelling and expression were made in line with the suggestions. A pilot study was conducted with 18 third and 22 fourth-graders at a different school from the participants before the application to check whether the questions were understandable, to determine the suitability for the level of the students and whether they could be solved by the students. Item analysis of the questions was made by using Henryson method. The item difficulty index was found to be 0.41. According to the Henryson method, the item difficulty index is the ratio of those who answered the item correctly to the total number of respondents. This index can take values between 0 and 1. As the item difficulty index approaches 0, it can be interpreted that the item is a difficult item and as it approaches 1, it can be interpreted as an easy item. An item difficulty index of around 0.50 is a sought-after feature in studies (Hasançebi, Terzi & Küçük, 2020). The reliability coefficient of the test was found to be .86 as a result of the CR-20 analysis performed to find out the reliability coefficient of the test. According to Kalaycı (2008), the reliability coefficient value being between 0.80 and 1.00 indicates that the measurement tool is highly reliable. In this direction, the final version of the "problem-solving test" was obtained without removing any question items, since it was desired to be suitable for each student's level.

3.4. Data Collection Process

Necessary permissions were obtained from the administrators and teachers, participants and their families in the schools where the application would be carried out, and necessary information was given by the researcher. After the necessary information was given, the "problem-solving test" was applied individually to the third and fourth-graders through their classroom teachers. The application period of the data collection tool lasted 1 lesson hour (40 minutes) for each student. The classroom teachers were asked not to be directive about the answers of the students during the application. The data were collected by delivering the problem-solving test containing the answers of the students to the researcher by the classroom teachers. The researcher was not present in the classroom in order not to distract the students during the data collection process. According to Büyüköztürk et al., (2021) in qualitative research, the presence of the researcher and the participants in the same environment cause the behavior of the participants to change.

3.5. Data Analysis

In the analysis of the data of this study, which aimed to find out the problem-solving strategies of the third and fourth-grade students of primary school, the descriptive analysis technique, one of the qualitative analysis techniques, was used. In the process of descriptive analysis, the researcher creates a framework based on a certain conceptual framework, the data is read, edited and defined (Yıldırım & Şimşek, 2021). The data obtained from the students participating in the research were organized by labeling as Ö1, Ö2, The answers given by the students to the problem-solving test, which is the data source, were examined. It was determined which problem-solving strategy was used and how often.

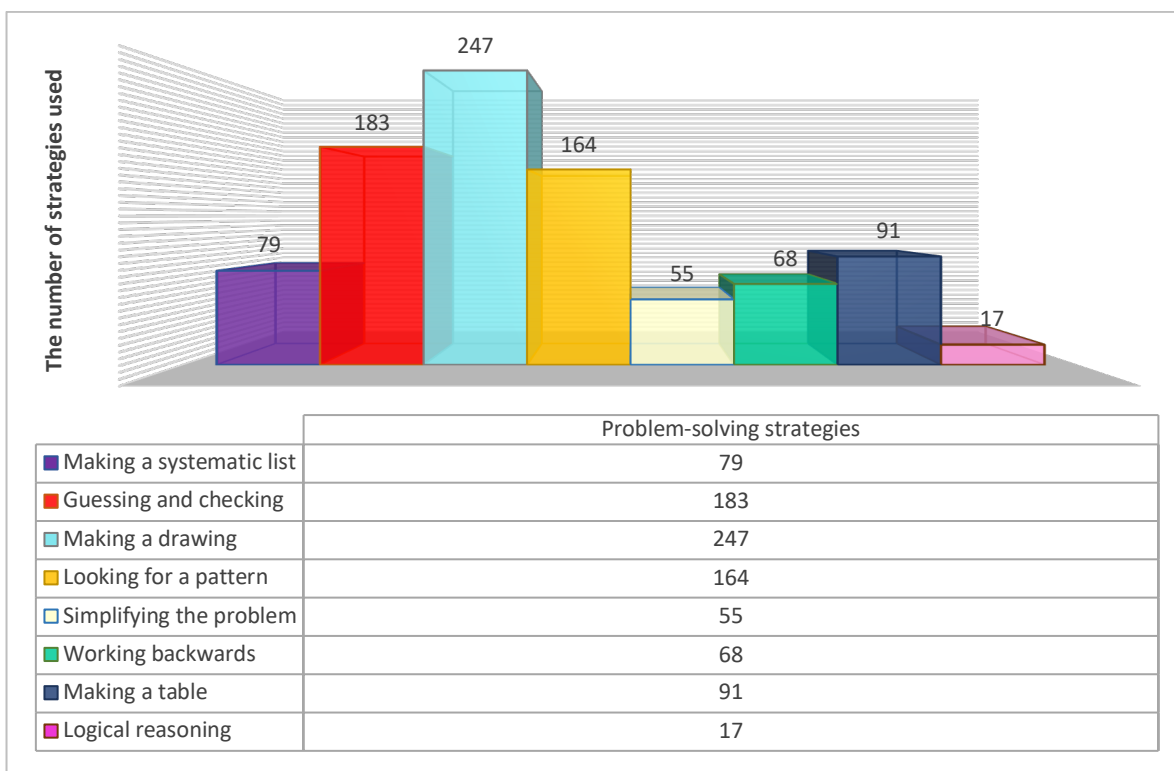
3.6. Validity and Reliability

To ensure reliability, randomly selected samples from student's answers were analyzed at different times and the results were compared. The most useful method to increase reliability in qualitative research is member checking (Gibbs, 2007; Miles & Huberman, 1994). Another researcher, who is an expert in mathematics education, was provided to analyze the data and reach the results in order to ensure reliability. Miles and Huberman (1994) reliability formula ($\text{Reliability} = \frac{\text{Consensus}}{(\text{Agreement} + \text{Disagreement})} \times 100$) was used to calculate the consistency between two analyzes and the consistency value was determined as 91.61%. This shows that the results of the research are reliable. According to Miles and Huberman (1994) if the reliability calculations are over 70%, it is considered reliable for the research. To ensure the credibility of the analysis results of the data, the photographs from the raw data sources were included in the findings section.

4. Findings

In this part of the research, in line with the data obtained by examining the answers given by the students to the problem-solving test, the strategies used by the 3rd and 4th-grade students in non-routine problem-solving are presented. Which strategies were used and the number of strategies used by primary school 3rd-grade students were given in Graph 1.

Graph 1. Problem-solving strategies used by primary school 3rd-grade students



When Graph 1 was examined, it was seen that primary school third-graders used mostly the strategy of making a drawing (247 times) in solving non-routine problems. This strategy was followed by the following strategies: guessing and checking (183 times), looking for a pattern (164 times), making tables (91 times), making a systematic list (79 times), working backwards (68 times), simplifying the problem (55 times) and the least used logical reasoning (17 times). Examples of the strategies used by third-grade students are given in Figure 1.

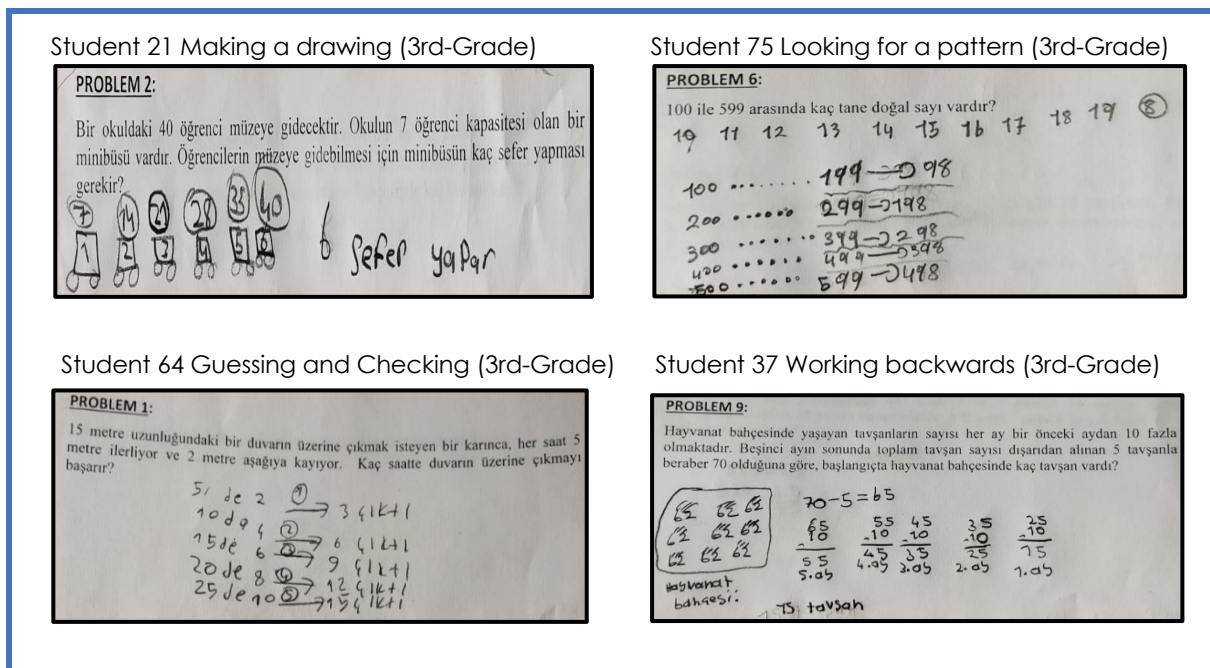
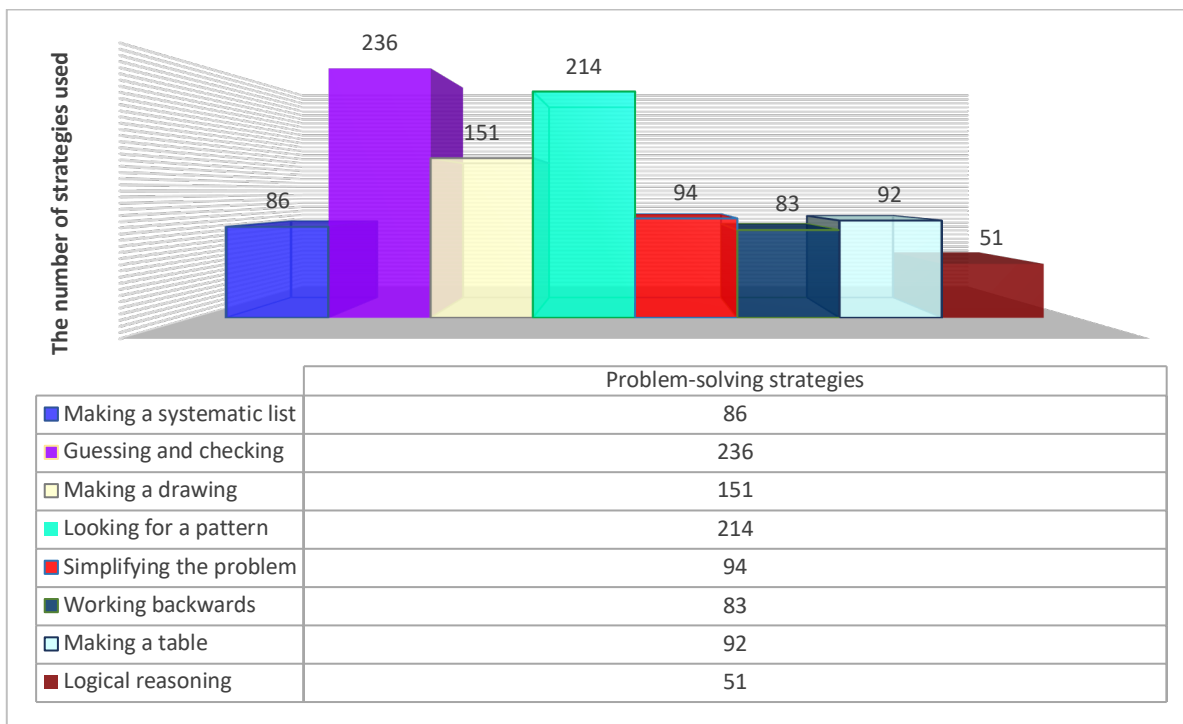


Figure 1. The examples of the strategies used by the 3rd-grade students

Which strategies were used and the number of strategies used by primary school 4th-grade students were given in Graph 2.

Graph 2. Problem-solving strategies used by primary school 4th-grade students



When Graph 2 was examined, it was seen that primary school fourth-graders used mostly the strategy of guessing and checking (236 times) in solving non-routine problems. This strategy was followed by the following strategies: looking for a pattern (214 times), making a drawing (151 times), simplifying the problem (94 times), making a table (92 times), making a systematic list (86 times), working backwards (83 times) and the least used logical reasoning (51 times). Examples of the strategies used by fourth grade students are given in Figure 2.

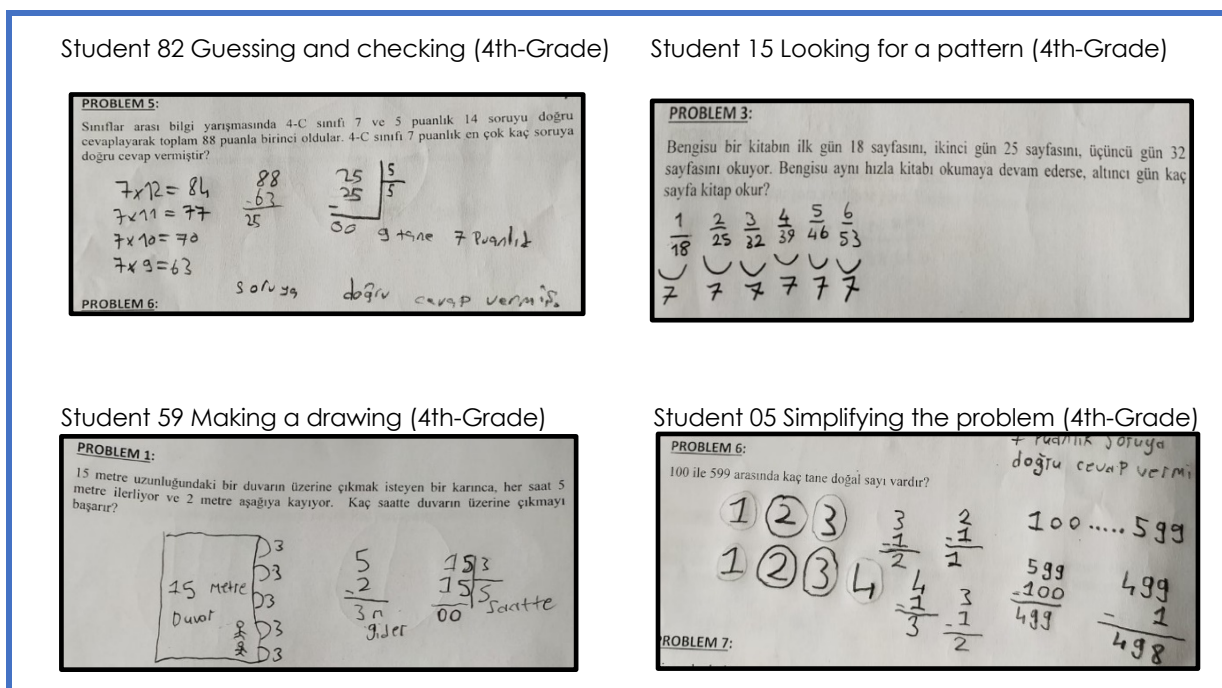
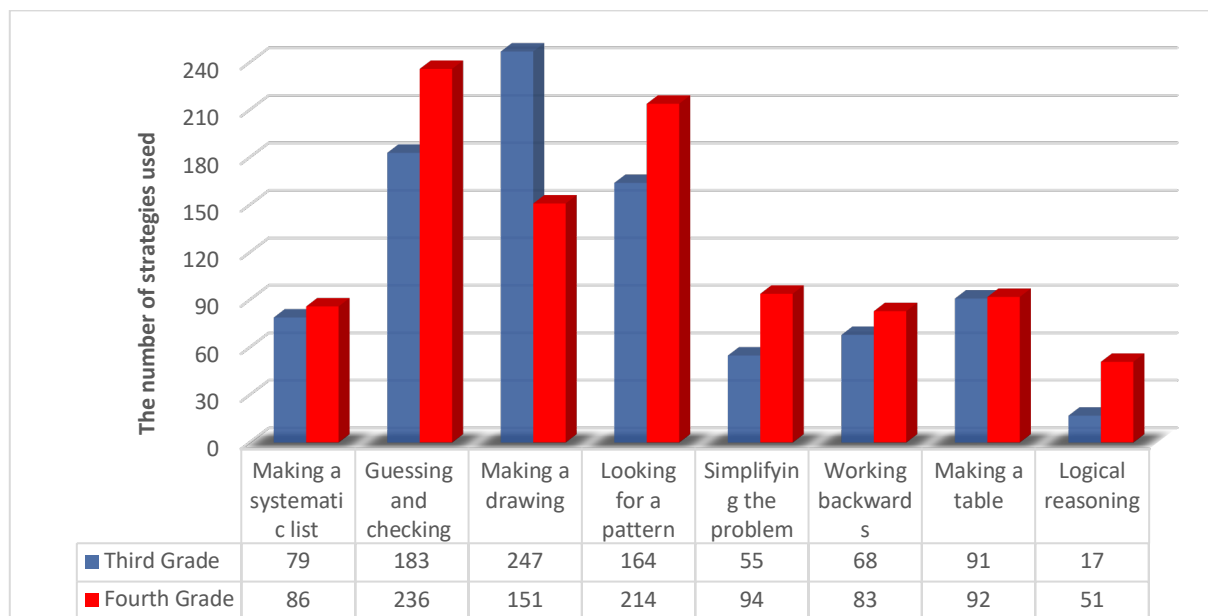


Figure 2. The examples of the strategies used by the 4th-grade students

The comparison of problem-solving strategies used by primary school 3rd and 4th-grade students was given in Graph 3.

Graph 3. The comparison of problem-solving strategies used by primary school 3rd-grade and 4th-grade students



When Graph 3 was examined, it was seen that primary school fourth-graders were more likely to use other problem-solving strategies apart from making a drawing than the third-graders. It was discovered that making a systematic list was used by 79 third-graders and 86 fourth-graders. Checking and guessing was used by 183 third-graders and 236 fourth-graders. Looking for a pattern was used by 164 third-graders and 214 fourth-graders. Simplifying the problem was used by 55 third-graders and 94 fourth-graders. Working backwards was used by 68 third-graders and 83 fourth-graders. Making a table was used by 91 third-graders and 92 fourth-graders and the frequency of usage was close to each other. Logical reasoning was used by

17 third-graders, 51 fourth-graders. The examples of comparison of problem-solving strategies used by third and fourth-grade students are given in Figure 3.

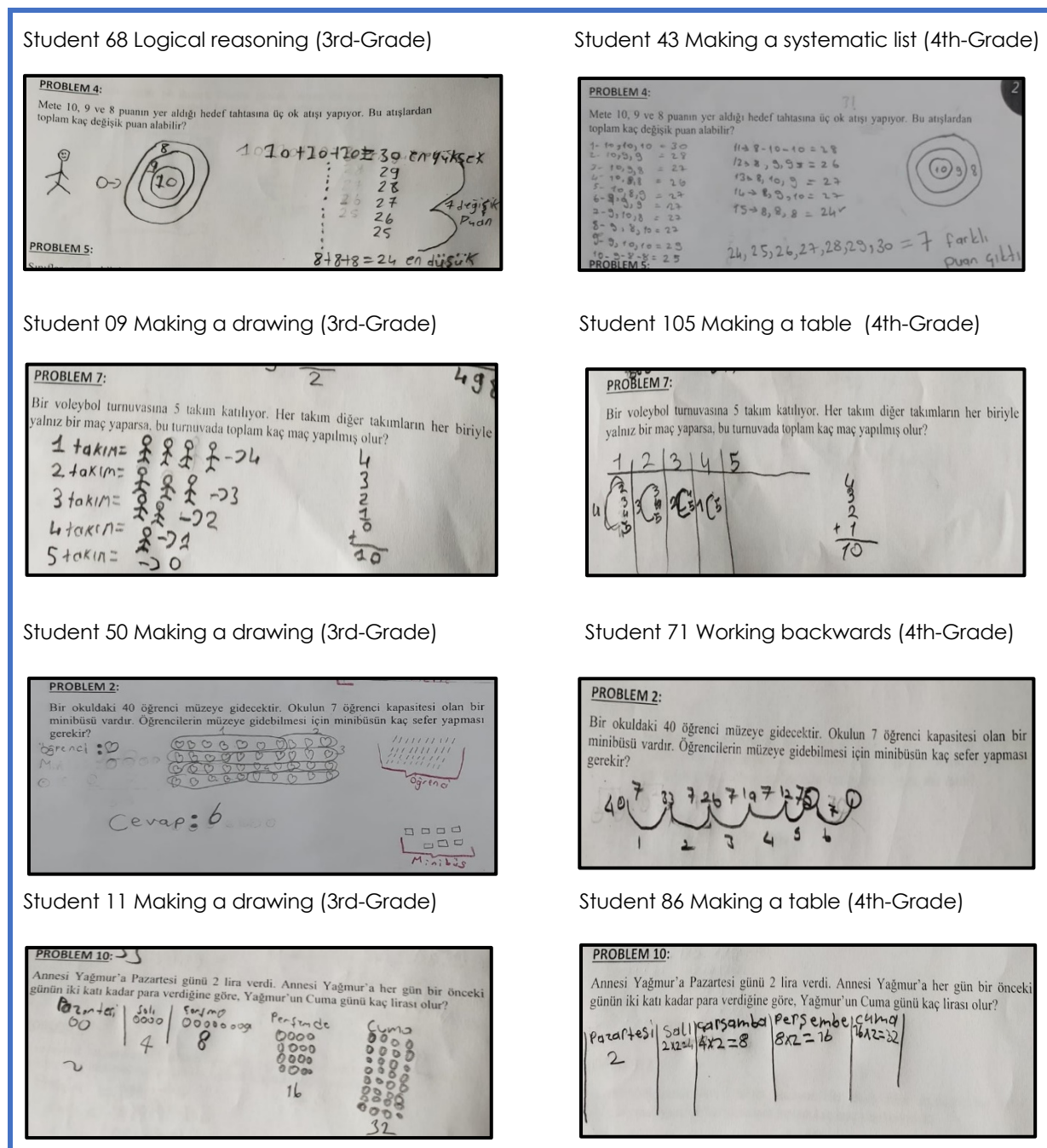


Figure 3. The examples of comparison of problem-solving strategies used by 3rd-grade and 4th-grade students

5. Discussion

When the results of the research were examined, it was discovered that primary school third-graders used mostly the strategy of making a drawing and the strategies of guessing and checking and looking for a pattern were the most frequently used strategies after this strategy in solving non-routine problems. In a study conducted by Swanson, Lussier & Orosco, (2011) with 120 second and third-graders, the problem-solving success of students, who had and did not experience mathematical difficulties, improved by teaching the use of visual strategies. Csaba, Sztányi & Rita (2012) stated that 3rd-grade (9-10 years old) students developed their

knowledge about problem-solving strategies as a result of the teaching by emphasizing the role of visual representations in mathematical modeling in the context of the problem-solving. In the studies of Altun, Bintaş, Yazgan and Arslan (2004), it was observed that students aged 6-7 years were able to present unique initiatives for problems and that the problem-solving strategies of students in both age groups were quite similar to each other. Again, the results showed that the modeling strategy has an important power to make the right solution for these age groups and to explain the opinions of the students. Çelebioğlu, Yazgan, and Ezentaş (2010), in their study with 170 first-graders, concluded that the most successful strategy used by first-graders in solving non-routine problems is to looking for patterns.

When the problem-solving strategies used by primary school fourth-graders were examined, it was discovered that guessing and checking was the most frequently used strategy and it was followed by looking for a pattern and making a drawing. When problem-solving strategies between the two grade levels were compared, it was concluded that the frequency of using other problem-solving strategy apart from making a drawing of the primary school fourth graders was higher than the primary school third-graders. In the studies conducted by Altun, Bintaş, Yazgan, and Arslan (2004) with 8- and 9-year-old students, it was investigated to what extent students could comprehend and apply problem-solving strategies. As a result of the studies, it was observed that the strategies of working backwards, guessing and checking and making a systematic list could be learned at a higher level and the learning level of making a drawing and looking for a pattern remained low. In the study conducted with the 10 and 11 age groups, they concluded that the learning levels of making a systematic list, making a drawing, guessing and checking and simplifying the problem-strategies were at a higher level. Fagnant and Vlassis (2013) schematic representations was found to have a clear positive effect on overall student performance in grade 4 students. It was also found that a high percentage of students were able to reuse the encountered representations to solve new problems. Reuter, Wolfgang and Rasch, (2015), on the other hand, stated that teaching the use of drawings and tables as external representations in the solution of non-routine problems to primary school 4th-grade students did not facilitate problem-solving. Yazgan and Bintaş (2005) stated in their study that primary school 4th and 5th-grade students were able to use some problem-solving strategies informally even though they had not received any education. Despite efforts to promote problem-solving learning in schools, the evidence shows that students are still not competent enough to solve cognitively challenging problems such as non-routine problems (Eliä, Van den Heuvel, & Kolovou, 2009). In their research, Van den Heuvel-Panhuizen and Bodin-Baarends (2004) found that 4th-graders with high mathematics success in the Netherlands were able to show more limited skills than expected when faced with non-routine problems. In fact, they could not write almost anything on the solution of some problems and did not spend much effort to find a solution. According to Van de Walle, Karp and Bay-Williams (2014), students who sense that there is a method or approach preferred by the teacher are reluctant to use their own strategies. Students who notice that teachers think for themselves will not be able to develop their self-confidence and problem-solving strategies, in this way, their ability of thinking deeply will decrease. It is important to present the solution strategies in the form of classroom discussions to help students take more responsibility individually with such questions "How did you solve the problem?, Why did you solve it this way?, Why do you think your solution is correct and logical?".

6. Conclusion

In the primary school years, when the foundations of educational activities are laid and which will affect the future education life of students, it can be shown that there are other ways of thinking about the same problem by trying to solve problems with different solution strategies in mathematics. It can help to learn how to use different problem-solving strategies in solving a problem. Students can be encouraged to use different strategies by taking more place in the textbooks for the problems involving different types of problem-solving strategies. The discussing strategies in the classroom can help students learn about their friends' strategies and use those strategies later on. The role of teachers should be to help students develop their own approaches.

Limitation

This study is limited to primary school third and fourth grade students. Another limitation is that only the qualitative research method was used in the study. The lack of analysis with quantitative data can be considered a limitation.

Recommendation

The researches can be conducted in which more problems are used and the problem-solving strategies of students in different classes are examined.

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Conflict of Interest

The Author declares that there is no conflict of interest.

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