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Strategies 8th Grade Students Prefer in Problem Solving: A Descriptive Study

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Abstract

The aim of this study was to determine the level and frequency of the strategies secondary school students use in problem solving. Sixty-seven 8th grade students from four different public schools participated in the study. The data were obtained through the participants' answers to five non-routine problems that can be solved through using more than one strategy. Descriptive statistics were used in data analysis. It was found that the students mostly used setting up equations, conscious prediction and monitor, drawing figures or diagrams, and looking back strategies. On the other hand, they made little use of simplifying the problem strategy. The findings revealed that the participants made the greatest number of mistakes while using setting up equation strategy and the fewest number of mistakes while using finding patterns, reasoning and simplifying the problem strategies.

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Introduction

The problem obliges the student to use their existing knowledge and reasoning skills instead of an exercise or question the solution of which is already known (MEB, 2013; NCTM, 2000). Problem solving is not only one of the NCTM's Principles and Standards for School Mathematics but also is the basis of the mathematics teaching and learning process (Ratnasari & Safarini TLS, 2020). Thus, problem solving consists of all processes in the solution stage with the acquisition of adequate algorithms and methods (Arslan, 2021; Korkmaz, 2021; Polya, 1997). Problem solving is effective in the development of many thinking skills such as reasoning, establishing relationships, and analytical thinking, as well as the four arithmetic operations (Gürbüz & Güder, 2016; Karaca, 2012; Temiz & Ev Çimen, 2017). Therefore, problem solving has an important place in the curriculum and is one of the significant components of mathematics in providing students with the necessary knowledge and skills (Baki, 2015). In this sense, many educators appreciate the effort devoted to problem solving (Ersoy & Güner, 2014; Jonassen, 2000). Therefore, problem solving is the basis of mathematics teaching.

Although problem solving is an essential element of the mathematics course, knowing how to approach the problem, to recognize and use solution strategies is also important (Altun, 2010; Gümüş & Umay, 2017) due to the fact that different methods are used to solve all problems (Altun & Arslan, 2006; Kükey et al, 2019). Each student prefers to use the solution that he/she considers as the most suitable during problem solving. The appropriate use of strategies facilitates problem solving and ensures success (Altun & Memnun, 2008; Yazgan, 2007). Therefore, problem solving strategy is regarded as one of the important elements of the problem-solving process. In order to acquire and develop problem-solving skills, which are a part of an individual's mental activities, it is necessary to observe the problem-solving processes of individuals (Baş, 2016; Şengül & Işık, 2014).

Teachers generally prefer to ask questions from simple to complex. The solution time and method vary on the basis of the difficulty of the problem. In this sense, problems are divided into two categories: routine and non-routine (Altun, 2011; Mahlios, 1988; Yılmaz, 2019). Routine problems appear like an exercise, are used to reinforce what students have learned, and usually have only one solution. On the other hand, non-routine

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problems require the students to analyze the data carefully, think creatively and use multiple strategies (Artut & Tarım, 2006; Bayazıt & Şenberber, 2021; Inoue, 2005). Mathematics curriculum aims to enable students to use their thinking skills such as logical reasoning, reasoning and associating with real life at the desired level in the problem solving process (MEB, 2018). Therefore, non-routine problems that require students to think more deeply rather than simple thinking play an important role in the mathematics curriculum. In this sense, using non-routine problems in teaching is quite important with the aim that students can use what they have learned in new situations and develop their thinking skills.

Designs for solving a problem require the use of different strategies. Hence, multiple strategies may be used at the same time in problem solution. The following strategies are mentioned in the studies in the literature: making lists, forming tables, conscious guessing and checking, drawing diagrams, schematics or diagrams, finding patterns, establishing equations, simplifying the problem, looking back, reasoning (Altun, 2000; Arslan & Yazgan, 2016; Baykul, 2014). This study aimed to determine the strategies 8th grade students use in solving non-routine mathematical problems.

Method

Research design

The qualitative descriptive method design was used in the study. The qualitative descriptive method is a theoretical approach based on naturalistic investigations and views of something in its natural state (Lambert & Lambert, 2012). This type of research allows an in-depth and detailed analysis of a situation (Yıldırım & Şimşek, 2006; Yin, 2003). With this method was aimed at the description and interpretation of students' problem solving strategies to get a solution for five non-routine problems and with this to present the event summaries experienced by a group of people. In this context, how the students approached the problems in the problem solving process was examined in-depth and in detail.

Participants

The study was carried out with sixty-seven 8th grade students in four different schools in a city located in the Eastern Anatolian Region of Turkey. The easy sampling method was used in the selection of the participants. In this context, four schools were selected from close circles in terms of accessibility, and studies were carried out with randomly selected eighth-grade students from these schools. The number of the participants, schools and the mathematics course academic achievement of the students are given in Table 1. Each participant was coded as S1, S2, .., S67.

Table 1.
Schools, number of students and academic success of the students

School	Number of Participants	Academic Achievement in Mathematics
Elementary School A	24	3-4
Elementary School B	16	2-3
Elementary School C	14	2-3
Elementary School D	13	3-4

Data collection

A total of five non-routine mathematical problems, obtained from the textbook and other sources, were asked to the participants. Each problem was solved using at least three different strategies, and the strategies that can be used in solutions were as follows: setting up equations, working backwards, conscious guessing and checking, finding patterns, drawing figures, diagrams or diagrams, forming tables, reasoning, and simplifying the problem. Students were allowed to solve these questions in one class hour. The data were obtained by examining the students' answer in detail.

Prior to the application, theoretical information about the strategies was provided to the participants in two class hours. First, the

definitions of routine and non-routine problems and some examples were presented. Then, the problem-solving stages of Polya (1997), one of the most commonly used methods to facilitate the solution of non-routine problems - understanding the problem, devising a plan, carrying out the plan, looking back - were introduced to the students. How the steps of Polya (1997) could be used in a problem was explained. Then, a number of strategies that can be used in problems were introduced and some examples were presented. In this manner, participants were informed about problem solving steps and strategies through different examples and applications. This facilitated participants' problem-solving process and guided them about how they should approach the problems.

Data analysis

There is interpreted and described the event based on fact, and data analysis was presented descriptively. In this sense, the descriptive analysis method was used and the strategies used by the students were divided into the following categories: Successful solution, insufficient solution and incorrect solution. The categories were established on the basis of the study of Ersoy and Güner (2014). The definitions of the categories presented in Table 2.

Table 2.
The categories used in the study

Code	Definition	Solution
CSCS	Results with the correct strategy and correct solution	Successful solution
CSIS	Results with the correct strategy but incorrect solution	Insufficient solution
ISIS	Results with the incorrect strategy and incorrect solution	Incorrect solution

In the answers given by the students to the problems, first the strategies used by the students were identified and evaluated, then the used strategy used was classified and coded in line with the categories in Table 2. For example, if a student solved a question using the correct strategy, this solution was coded as CSCS. To analyze the cognitive process in problem solving, students' verbal expressions and solutions were investigated in detail. Then, the frequency of the applied strategies was determined and presented in tables. The strategies in the student solutions were evaluated on the basis of the following steps:

1) Identifying the used strategies
2) Deciding whether the strategy is appropriate for the problem
3) Determining whether the strategy is used correctly
4) Examining the reasons for insufficient and incorrect solutions
5) Determining the category of the student solution

Findings

The findings showed that some of the participants answered the problems successfully whereas others answered insufficiently or incorrectly. It was observed that those who answered successfully used different strategies in their own way, and that, those who answered insufficiently or incorrectly, could not get the exact result even though they tried to use the strategies. The strategies that students frequently use and the correctness of the solutions are presented in Table 3.

Table 3.
Strategies used by students

Strategies	CSCS *f*	CSIS *f*	ISIS *f*	TOTAL *f*
Setting up Equations	98	14	31	143
Conscious prediction and monitor	31	10	5	46
Drawing figure or diagram	18	15	8	41
Looking back	26	7	4	37
Forming tables	16	7	4	27
Reasoning	17	6	3	26
Finding patterns	15	2	1	18
Simplifying the problem	4	5	3	12

Table 3 shows that the most used strategy was setting up equations. The fact that although the participants used setting up equations widely, they obtained incorrect solutions revealed that this strategy was used incorrectly and was appropriate with the nature of the problem. Conscious prediction and monitor, drawing figures, diagrams or diagrams, looking back, forming tables, reasoning and finding patterns were among the other strategies that students used. It was found that although these strategies were mostly used successfully, some of them led to incorrect results as a result of incorrect solutions. It is noteworthy that although drawing figures or diagrams were used enormously, its misuse rate was high. Students used simplifying problem strategy less than other strategies. Some excerpts of student responses are presented in Figure 1.

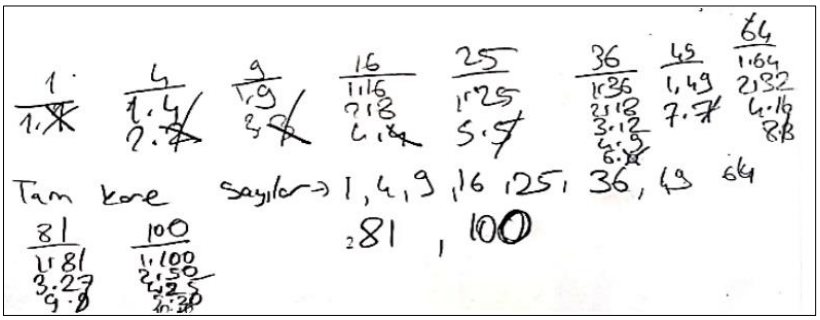

Figure 1. Successful solution through conscious prediction and monitor strategy (S5)

It is seen in Figure 1 that the correct result was obtained through using the prediction and monitor strategy. First, the student produced options for each door, and then using prediction and monitor strategy realized that the numbers whose door is open had the only multiplier. Through trial and error, the student, who could easily saw the numbers of doors whose doors are open and closed, recognized that in order to open the door of a cell whose door was at first closed, the lock must be turned an odd number of times. For example, it is clear that the door of cell 16 would be opened through this process whereas the door of cell 24 would remain unlocked. After discovering this kind of relationship, the student found that the number of guards unlocking cells 1, 4, 9, 16, 25, 36, 49, 64, 81, and 100, respectively, was an odd number using trial-and-error strategy and provided a solution to the problem.

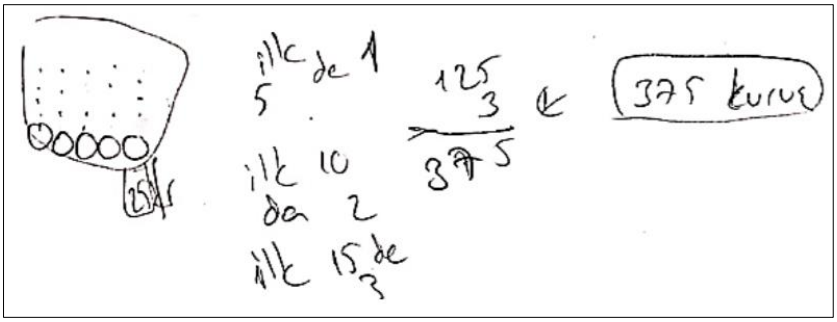

Figure 2. Insufficient solution through drawing figures or diagrams strategy (S11)

Figure 2 showed that the incorrect result was obtained through drawing a figure or diagram strategy. The participants drew figures to better understand the question and tried to apply it. However, in the following steps, he/she clearly made a mistake. In the first two steps, he/she thought that there would be 5 different gums, nonetheless, he/she could not predict that there would be at least 3 gums of the same color as the ball which was picked first in the last step. In this sense, he/she considered that there would be 5 different gums, and concluded that he/she could obtain at least 3 gums of the same color with a total of 15 gums. Therefore, he/she could not provide the correct solution, obtaining the result as 375 kuruş.

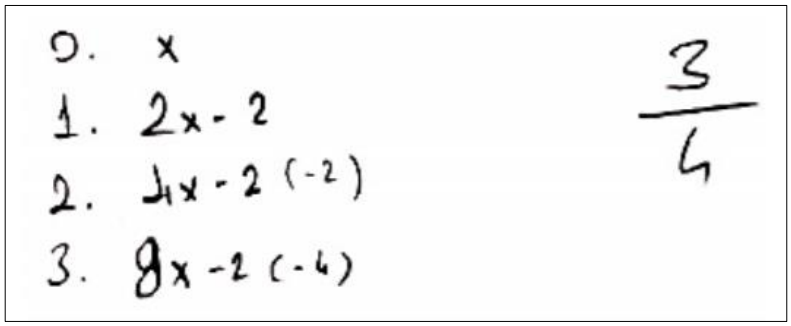

Figure 3. Incorrect solution through setting up equations (S37)

It is seen in Figure 3 that the incorrect solution was obtained through setting up equations strategy. The participant first named Enes' initial money at the beginning as "x" in order to state that it was unknown. Then, realizing that the existing money would be 2x when he crossed the bridge for the first time and he had to pay the toll for the bridge, he set up the equation 2x-2. However, after this step, the participant only took multiples of "x" lira she had determined at the beginning each time, instead of taking twice the amount of money Enes had (2x - 2). Due to this error, the participant set up the equation 4x-2 for the second pass over and 8x-2 in the third pass over. Therefore, the participant failed to provide the correct answer and irrelevantly provided the fractional expression as the answer.

Discussion

This Compared to other strategies, more frequent use of setting up equations strategy may be due to the fact that the participants regarded this strategy as a more reliable way. Another reasons for the frequent use of setting up equations may be that it is included in 8th grade Mathematics curriculum and that students considered setting up equations and problem solving as a shortcut. However, although it was frequently used by the students, a significant number of the participants made incorrect use of this strategy. The fact that participants thought that the problems require four arithmetic operations and they tried to solve problems in the way they solved routine problems may have inevitably led the students to insufficient or incorrect solutions. The habits participants developed in primary school can be considered among the reasons for frequent use

of looking back and conscious prediction and monitor strategies (Gür & Hangül, 2015). Primary school curriculum aims at developing students' prediction skills and their ability to investigate problems using different perspectives (MEB, 2018).

However, the findings of the present study revealed that although some students used these strategies, they could not provide the correct answer. This may be due to carelessness or incorrect thinking. In addition, the reason for selection of the strategy may vary depending on the nature of the problem or the student level (Durmaz & Altun, 2014). However, the fact that some participants failed to provide correct solution although they used these strategies reveals that there may be some difficulties in the use of these strategies. This finding is consistence with other studies in the literature (De Bock et al, 1998; Elia et al, 2009; Erdoğan, 2015).

Another strategy preferred by the participants was drawing a figure or diagram. However, most students made an incorrect use of this strategy possibly due to the difficulties they experienced while forming figures. Problems with long text and a lot of data may be a problem for using drawing a figure or diagram. The questions which are not appropriate to students' level and age may be another reason that make solution of these kind of problems difficult. It was found that simplifying the problem strategy was not used much, and when it was used, the participants mostly obtained incorrect results. This may be due the fact that the logic of simplifying the problem strategy was not well understood or the students did not think that they could use this method. Also, students have not been familiarized with the non-routine problems and problem solving strategy, this situation may be a result of.

The fact that students apply different strategies and use some strategies heavily can be associated with the nature of the problem, the student's knowledge of strategy, or the habits he has. Some studies on strategies also confirm this situation. For example, Arslan and Yazgan (2015) concluded in their study that students preferred "look for a pattern" and "make a drawing" strategies more often, and they included fewer strategies for "simplifying the problem" and "write an equation". On the other hand, Ratnasari & Safarini TLS (2020) stated that "draw a model, act it out, and guess and check" strategies are used more frequently. Ratnasari and Safarini TLS (2020) also pointed out the students' lack of strategy knowledge by stating that students use strategies by making use of similar problems that they have solved before. It is predicted that more strategies will be used in solutions with the teachers' inclusion of problems that require multiple strategies in their lessons and the expansion of students' strategy knowledge.

Conclusion

It was concluded as a result of this study that the students mostly used setting up equations strategy, followed by conscious prediction and monitor, drawing a figure or diagram and looking back. The fact that the students used forming tables, reasoning and finding patterns showed that the students did not ignore other strategies. Even though drawing a figure or diagram strategy was preferred by the participants, it was misused by most of them. On the other hand, simplifying the problem strategy was not preferred much.

Limitations and Future Research

This study was limited to 4 schools, 67 8th grade students and particular problems. Future studies should involve different grade levels and different types of problems. Introducing different strategies to students and applying them can pave the way to the use of different strategies and can help them eliminate many difficulties in the solution process (Altun, 2010). Especially, focusing mainly on routine problems in lessons may restrict students' approach to different problems (Altun et al, 2004). Students may feel the need to use rules every time they face a problem (Gür & Hangül, 2015). The frequent use of test-type exercises in the lessons may cause students to have difficulties in solving questions that they have not encountered before, and to be unable to reason with open-ended questions. The frequent use of multiple-choice type activities in the lessons may lead students to have difficulties in solving questions that they have not encountered before, and to have difficulties in reasoning in open-ended questions. In order to avoid all these problems, students should be exposed to open-ended problems in mathematics classes as much as possible and

they should be included in the solution process. In this sense, teachers are expected to give non-routine problems to the students that can promote multiple problem solving strategies when solving mathematical problems. In this sense, teachers are expected to give non-routine problems to the students that can promote multiple problem solving strategies when solving mathematical problems. Teachers should guide students to realize problem solving systematic and develop the skills to use strategies while using this systematic.

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