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Investigation of Four Operation Problem Solving Skills of Primary School Fourth-Grade Students According to Unknown Situation[1]

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Abstract

Problem solving skill is a basic skill that students should acquire both in mathematics education and their daily lives. This research aims to examine fourth-grade elementary school student skills in solving four-operation problems prepared in different structures according to the situation of the unknown. In this research, on the one hand, students' success in solving four-operation problems prepared according to the unknown (initial, change, and final unknown) was examined, and on the other hand, problem solutions were analyzed according to Polyo's problem solving steps. This research is a survey model from quantitative research methods. The sample of this research consists of 150 students studying in the fourth grade of two public primary schools in Amasya city center in the 2021-2022 academic year. The "Problem-Solving Achievement Test" developed by Bayar (2022) was used as a measurement tool in this research. Based on the findings obtained because of the analysis of the data; it was determined that students were significantly more successful in problems with unknown outcomes than in problems with unknown both initial and change. Besides, although the students were successful in the step of understanding the problem in the problem-solving steps, they were less successful in the steps of planning, executing the plan, and controlling the plan, respectively, compared to the step of understanding the problem. A positive relationship was found between all the variables in this research, albeit at a moderate and low level. It would be beneficial to revise the problems in the textbooks and classroom practices within the framework of the results.

Keywords: Problem solving, problems with unknown start, change and result, problem solving steps

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Introduction

Our daily lives are full of mathematical problem-solving. In today's world, all the major issues of making purchases, choosing insurance, health plans, retirement, or business require individuals with mathematical competence and the ability to solve real-life problems. Therefore, mastering the skills necessary for problem-solving during the school years is crucial for functioning effectively in society. Today, the ability of all students to construct new mathematical knowledge through problem-solving, to solve problems that arise in mathematics and other contexts, to apply a variety of appropriate strategies to solve problems, and to monitor and reflect on the process of mathematical problem-solving is coming to the fore, making problem-solving a desirable goal of school programs (Smith, 2001). Many countries include problem solving skills as one of the main objectives in their education programs (OECD, 2010). Perker (2009) stated that the importance of problem solving is increasing in the world mathematics and problem solving is an important part of the renewed curriculum in our country. In the program, it is stated that students will be able to explain their own ideas and reasoning during the problem-solving process and become aware of the deficiencies or weaknesses in the reasoning of other individuals. In addition, it is also stated that students will develop a positive attitude towards mathematics course thanks to their mathematics experiences and develop a self-confident approach to mathematical problems [Ministry of National Education (MoNE), 2018]. Similarly, Özsoy (2007) stated that one of the goals in the field of education is to raise well-equipped individuals who can find solutions to the problems they may encounter in the future and apply the necessary skills.

Problem-solving is the process of recognizing the problem, collecting information for the solution, selecting the appropriate solution path and putting this path into practice, and evaluating the result obtained (Evre, 2015). Problem-solving skill is a special cognitive skill that helps to cope with new situations and find appropriate solutions (Elkin & Karadağlı, 2015). Cooper (1986) defined problem-solving as the first attempt to solve an unknown question in situations that require following a series of activities. Problem-solving skill includes multiple skills. Problem-solving entails not only the knowledge of strategies for solving problems but also the ability to acquire new knowledge, use the acquired knowledge, and solve new problems through this knowledge (Molnar, Greiff, & Csapo, 2013). Kilpatrick (2004) stated that a student's success in problem-solving is related to the development of skills in the problem-solving process (as cited in Erümit & Nabiyev, 2015). For this reason, there are different views on the problem-solving process.

Steps in Problem Solving Process

For students to be successful in problem-solving, many studies view problem-solving as a chain of progressive activities. Although the steps in the problem-solving process change in different studies on problem-solving (Dickson Brown & Gibson, 1984; Mastropieri & Scruggs, MoNE, 2016; 2018; Xin, 2016), it is seen that Polya (1957) is united in problem-solving steps. These steps are:

- Understanding the Problem: At this stage, what is given, what is required, and the conditions, if any, are presented. The individual re-explains what he/she understands about the problem with his/her expressions, words, and figures (Baki, 2015).
- Making a Plan: In this step, a road map is created for the solution by establishing a relationship between what is given and what is desired. The strategies determined in the planning stage and their application in the implementation stage of the plan are the cognitive activities that an individual puts forward in solving a problem (Altun, Memnun, & Yazgan, 2007). Since problem-solving skills are closely related to planning skills, students need to be successful in planning to be good problem-solvers (Ataman, 2018).
- Executing the Plan: The solution is made by applying the planned steps. Tables and graphs to be used for the solution are drawn. The solution to the problem is tried to be reached by using the established equations or formulas. In summary, it is checked whether the tables, graphs, or formulas help solving equations (Baki, 2015).
- Checking the Accuracy of the Result: All processes are checked. A discussion is held about whether the result is logical or not. Perhaps the most important step, and one that is often overlooked by students, is to check whether the answer reached in the third step is the real answer to the problem understood in the first step (Van de Walle, Karp, & Bay-Williams, 2014).

This model put forward by Polya (1957) certainly offers a theoretical perspective to explain how the problem-solving process works and the nature of the ideas and practices in the process. However, it should not be concluded that there is a strict hierarchy between the stages of the problem-solving process and that one cannot move on to the next stage without completing what needs to be done at one stage. Individuals can switch back and forth between the steps of the problem-solving process and manage this process in a flexible and versatile way by using different techniques and strategies at each stage (Bayazıt & Aksoy, 2010). In the problem-solving process, the accuracy of the solution is valued. However, the way of solution, what occurs in the student's mind while solving, understanding of the problem, and the strategies he or she uses to solve the problem are also highly important (Özsoy, 2002). Problem-solving does not only consist of producing solutions but also requires thinking about all stages of the solution process (Çakmak, 2003). When evaluating students' problem-solving skills, it is significant to give information about the mistakes, misconceptions, and the steps (understanding the problem, making a plan, implementing the plan, and evaluating the plan) that students make while solving problems (Göktürk et al., 2015). The teacher finds the opportunity to see the types of mistakes made by the students while they are solving problems, thinking aloud, or checking the solved problem. In this way, according to the results of the evaluation of the mistakes made by the students during the problem-solving phase, they can be corrected in a way to gain the proper perspective (Çakmak, 2003). In addition, having information about all stages of the problem-solving process and seeing what kind of mistakes they make in this process will contribute to the student's ability to solve new problems they

will encounter later without any difficulties. Another key point in problem-solving is that students change in their ability to solve different types of problem. Students' problem-solving skills also differ according to problem type. In addition, students' problem-solving skills also vary according to the type of problem and the type of unknown in these problems (Haylock & Cockburn, 2004; Nures & Brgant, 2008; Sarama & Clements, 2009). Similarly, Riley, Greeno, and Heller (1983) emphasized that the degree of difficulty of a problem is highly affected by the position of the unknown or the role of quantity in the problem.

Problems According to Unknown Situation

The fact that four-operation problems have different meanings, variety, and different structures are among the reasons why children face difficulties in such problems. One of the different forms of problems can be considered as the unknown. In this context, in the literature, Jitedra and Hoff (1996) divided problems into three categories according to the location of the unknown: problems with unknown start quantity, problems with unknown change quantity, and problems with unknown result quantity. Riley, Greeno, and Heller (1983) defined result-unknown problems in which the unknown quantity is the result of the situation described in the problem or the result of arithmetic operations, and initial unknown problems in which the unknown quantity refers to the quantity required to indicate the relationship. According to Nathan and Koedinger (2000), result-unknown problems can be solved with the direct execution of mathematical operations and these problems can be considered as arithmetic level problems. Problems with unknown initial unknowns tend to abolish the simple modeling and direct calculation approaches of arithmetic problems. They often require the use of algebraic methods and more complex modeling.

İskenderoğlu, Akbaba, and Olkun (2004), in their research on 3rd, 4th, and 5th-grade students' choice of operations in routine problems, stated that problems with different structures should be included in the classes and that students who solve problems with different structures will improve their ability to solve problems in daily life. Similarly, Temiz and Ev Çimen (2017) stated that students will find the opportunity to develop their skills in formulating formulas, finding solutions, making assumptions, and generalizing during problem-solving activities. Hence, it is important to know the types of problems and to ensure that different problems are included in the textbooks. Bal and Dinç-Artut (2022) examined primary school students' ability to solve verbal arithmetic problems. The students were asked to solve verbal arithmetic problems of addition (result unknown - start unknown - change unknown), separation (result unknown - start unknown - change unknown), part-part-whole (large unknown, small unknown, difference unknown), and comparison (exact unknown-difference unknown). According to the results of the study, students were most successful in combination problems and least successful in part-part whole problems. In addition, the researchers stated that students' success in solving arithmetic- verbal problems increased as students' mathematics achievement and grade level

increased. When these results are analyzed, it is clear that all verbal problems should be included in the textbooks. When the related literature is scrutinized, Temiz and Ev Çimen (2017) examined the fifth-grade students' ability to solve different types of problems in their study in which they examined the students' ability to solve one routine problem and three non-routine problems (containing missing information, containing too much information, and having no solution). As a result of the study, it was determined that students had the most difficulty in understanding the unsolvable problems and spent the most time solving these problems. In addition, it was found that students with low academic achievement had difficulty understanding problems with missing or excessive information. Furthermore, in studies examining students' problem-solving skills, it is emphasized that different types of problems should be included more frequently in the classroom environment and textbooks (Karakoca, 2011; Koç, 2015; Şener & Bulut, 2015; Taşkın, Aydın, Akşan, & Güven, 2012; Uğur, 2018; Vural, 2019). However, when the literature is examined, it is noticeable that there are not many studies that examine problem-solving skills according to the unknowns of problems requiring four operations, that is, start, change, and result unknowns.

When the related literature is explored, it is seen that the studies with problems requiring four operations were mainly conducted in secondary education (Alkan, 2019; Akkan, Çakıroğlu, & Güven, 2009; Çelik & Güler, 2013; Göktürk, Örnek, Hayat, & Soylu, 2015; Karakılıç & Arslan, 2019; Karakoca, 2011; Sezgin-Memnun, 2014; Şener & Bulut, 2015; Umurberk, 2020; Uzun, 2010; Özdişçi & Katrancı, 2020; Öztürk, Akkan, & Kaplan, 2018). On the other hand, it is noteworthy that the number of studies examining four-operation problem-solving skills at the primary school level according to Polyo's problem-solving steps is not at the desired level (Dönek, 2018; Sezgin-Memnun & İlksen-Kanbur, 2020). Therefore, this study aims to contribute to the literature by examining primary school fourth-grade students' ability to solve four-operation problems prepared according to unknown conditions (initial unknown, change unknown, and result unknown) and the problem-solving process according to Polyo's problem-solving steps. Additionally, in light of the data obtained from this study, it will shed light on the regulation of the importance of problem structures and problem-solving steps that classroom teachers deal with in their lessons.

Purpose of the Research

The purpose of this research is to examine the 4th-grade elementary school student's ability to solve four-operation problems prepared according to the unknown (start unknown, change unknown, and result unknown) and their problem solutions according to the problem-solving steps (understanding the problem, making a plan, executing the plan, and checking). For this purpose, answers to the following research problems were sought:

1. What is the level of fourth-grade students' solving problems prepared according to the unknown situation of four operations problems?

2. What is the level of fourth-grade students' solving four operations problems according to Polyo's problem-solving steps?
3. Is there a relationship between the problem-solving steps of fourth grade students' problems prepared according to the unknown situation of four operations problems?

Methodology

Under this title, the model of the research, the participants of the research, data collection tools and the analysis of the data were mentioned respectively.

Model of the Research

This research aimed to examine the 4th-grade elementary school student's ability to solve four operations problems prepared according to unknown situations (start unknown, change unknown, and result unknown) and to analyze these problems according to problem-solving steps. The current research is a descriptive study in the survey model. Studies that examine the views of participants on a subject or an event or their interests, abilities, attitudes, concerns, etc. are called survey studies (Büyüköztürk et al., 2013).

The Participants

The participants of this research are consisted of 150 fourth-grade students in two public primary schools in the center of Amasya province in the 2021-2022 academic year. The convenience sampling method was used to select the sample group. Convenience sampling is a sampling that is easy to reach, available, and conducted on people who want to participate in the study (volunteers) (Christensen, Johnson, & Turner, 2015). The demographic information of the participants is shown in the table below.

Table 1. Demographic Characteristics of the Students Participating in the Research

Gender	**f**	%	**Number of Family Members**	**f**	**%**
Female	62	41	3 people	48	32
Male	88	59	4-5 people	84	56
Father Education Level	**f**	**%**	6-7 people	18	12
Primary School	16	11	**Having a Bookcase**	**f**	**%**
Secondary School	12	8	Yes	115	77
High School	50	33	No	35	23
University	72	48	**Number of Books Read in a Month**	**f**	**%**
Mother Education Level	**f**	**%**	4-6	24	16

Primary School	24	16	7-9	36	24
Secondary School	18	12	10-12	50	33
High School	65	43	13-15	40	27
University	43	29			

When Table 1 is analyzed, it is clear that the sample group of this research consists of 62 female and 88 male students. When the education levels of the students' fathers are examined, it is seen that 16 of them are primary school graduates, 12 of them are middle school graduates, 50 of them are high school graduates, and 72 of them are university graduates. When the maternal education levels of the students are examined, it is observed that 24 of them are primary school graduates, 18 are middle school graduates, 65 are high school graduates, and 43 are university graduates. Given the number of people in the family, it was observed that 48 of the students lived with 3 people, 84 of them lived with 4-5 people, and 18 of them lived with 6-7 people. When the students' having a library is analyzed, it is seen that 115 of them have one and 35 of them have not. When the number of books the students read in a month was analyzed, 24 of them read 4-6 books, 36 of them read 7-9 books, 50 of them read 10-12 books, and 40 of them read 13-15 books.

Data Collection Tools

In this research, the routine problem-solving achievement test developed by the researchers was used to determine the student's ability to solve four operations problems prepared according to the unknown situation (initial unknown, change unknown, and result unknown).

Problem Solving Achievement Test

The Problem-Solving Achievement Test used in the research was developed by the researchers and used to determine the problem-solving levels of the students. The problems in the test is consisted of routine and verbal problems limited to the relevant grade level outcomes requiring four operations. First, the researchers created an item pool by examining mathematics test books (Berkay, 2021; Model, 2021; Tudem, 2021). Subsequently, 36 of the questions in the item pool were selected and a problem-solving achievement test was developed. In addition, 3 Turkish education experts, 2 mathematics education experts, and 2 classroom teachers were interviewed, and their expert opinions were taken in terms of the level of the questions and their suitability for reading comprehension, and the achievement test, which initially consisted of 36 items, was reduced to 24 because of the arrangements made. Thus, the problem-solving achievement pretest used for this research included 24 multiple-choice questions, each with four options and equal points.

The questions in the achievement test created as a result of the above process steps were prepared based on the achievements in the 4th-grade mathematics program of the Ministry of National Education. The questions in the test are appropriate for addition, subtraction, multiplication, and division, that is, four operation skills. The test included questions about finding the result unknown, change unknown, and start unknown. In addition, the questions in the test were prepared following each of Polyo's (1957) problem-solving steps (understanding the problem, making a plan, executing the plan, and checking). The problem-solving steps and the status of the questions in the final version of the achievement test are given in Table 2.

Table 2. Problem Solving Achievement Test Specification Table

Problem Solving Steps / Sub Categories	Result Unknown (a+b=?)	Change Unknown (a+?=c)	Start Unknown (?+b=c)
1. Understanding	2.,4. Questions	3. Question	1.,5. Questions
2. Making a plan	6.,8. Questions	7.,9. Questions	10. Question
3. Executing the plan	13. Question	11.,14. Questions	12.,15. Questions
4. Checking	16.,18. Questions	17.,19. Questions	20. Question

For the pilot study, the questions in the test was pretested to 120 students. For the validity study, the achievement test scores of the students were calculated and ranked from highest to lowest; 27% of the papers with the highest and lowest scores were separated and the upper and lower groups were determined. Item analysis was performed with the percentages of correct answers in the upper and lower groups and item discrimination levels were calculated. As a result of the validity and reliability studies conducted with 120 students, it was determined that the item discrimination level of the test ranged between .18 and .57, with an average difficulty of .49. As a result of the analysis, 4 questions whose item difficulty indices and discrimination levels were not appropriate or needed to be corrected were removed from the test and the test was finalized. Thus, the achievement test used for the research consists of 20 questions. The KR-20 reliability coefficient is 0.758.

Data Analysis

The quantitative data obtained to answer the problems identified in line with the purpose of the research were analyzed using the Statistical Package for the Social Sciences Version 21.0 (SPSS 21.0) package program. In the research, the data was first recorded in MS Office Excel program and some frequency percentage tables were prepared in this program. The entered data was then transferred to the SPSS 21.0 program and analyzed. Kolmogorov-Smirnov (K-S) test and Levene's test were used to determine whether the data was normally distributed. Since the data related to the unknown situation and problem-solving steps was normally distributed, a one-way analysis of variance (ANOVA) was

applied. One-way analysis of variance tests whether the difference between two or more unrelated sample means is significantly different from zero (Büyüköztürk, 2015). The significance level was accepted as 0.05 in the significance tests applied.

Results

In this part of the research, the findings obtained from the problem-solving achievement test are given. In accordance with the sub-problems determined during the research, the findings are presented under three sub-headings.

Fourth-grade students' levels of solving problems prepared according to the unknown situation of four operations problems

The results of the ANOVA test for the differentiation of students' mean scores on the "Problem-Solving Achievement Test" according to the unknown status of the four operation problems are given in Table 3 and Table 4.

Table 3. Descriptive Statistics of Routine Problem-Solving Achievement Test Scores According to Unknown Situation

	N	Average	Standard deviation
Start Unknown	150	3,17	1,42
Change Unknown	150	3,23	1,36
Result Unknown	150	4,01	1,39
Total	450	3,47	1,44

Table 4. ANOVA Results of Routine Problem-Solving Achievement Test Scores According to Unknown Situation

Source	Total Squares	Sd	Average Square	F	p	Significant Difference
Intergroups	65,40	2	32,70	16,79	,000	SB-BB SB-DB
In-Groups	870,66	447	1,95			
Total	936,06	449				

According to the results of the analysis, there is a significant difference between the students' solving the problems with start unknown, change unknown, and result unknown, $F(2,44)=16.79$ $p<.01$. In other words, students' problem-solving success varies significantly according to the unknown in the problem. According to the results of the Scheffe test conducted to find out between which groups the inter-unit differences were, it was determined that students were more successful in problems with unknown result (X= 4.01) than both start unknown (X=3.17) and change unknown (X=3.23) problems.

Fourth-grade students' levels of solving four operations problems according to problem-solving steps

The results of the ANOVA test regarding the differentiation of students' routine achievement test scores according to the problem-solving steps of the four operations problems are given in Table 5 and Table 6.

Table 5. Descriptive Statistics of Routine Problem-Solving Achievement Test Scores Related to Problem-Solving Steps

	N	Average	Std. Deviation
Understanding the Problem	150	3,17	1,16
Making a plan	150	2,81	1,10
Executing the plan	150	2,28	1,30
Checking	150	2,13	1,49
Total	600	2,60	1,34

Table 6. ANOVA Results of Routine Problem-Solving Achievement Test Scores According to Problem-Solving Steps

Source	Total Squares	sd	Average Square	F	p	Significant Difference
Intergroups	104,75	3	34,91	21,48	,000	A.-P.U. A.- K P.Y-P.U P.Y-K
In-Groups	967,08	595	1,62			
Total	1071,84	598				

According to the results of the analysis, there is a significant difference between the student's problem-solving success in understanding the problem, making a plan, executing the plan, and checking the solution, $F(2,50)=21.48$ $p<.05$. In other words, students' problem-solving success varies significantly according to problem-solving steps. According to the results of the Scheffe test conducted to find out between which groups the differences between the units were, it was determined that the students were more successful in the steps of understanding the problem (X=3,17), executing the plan (X=2,28) and evaluating the solution (X=2,13). In addition, according to the results of the Scheffe test, it was determined that the students were more successful in the making plan step (X=2,81) than in the plan implementation (X=2,28) and checking (X=2,13) steps.

The relationship between problem-solving steps and problems prepared according to the unknown situation of fourth-grade students' four operations problems

Table 7 illustrates the descriptive statistics of the analysis of students' four operations problems prepared according to the unknown situation (start unknown, change unknown, and result unknown) and problem-solving steps.

Table 7. The Relationship Between Problems Prepared According to the Unknown Situation and Problem-Solving Steps

		Understanding the Problem	Making Plan	Executing the Plan	Checking the Solution
Start Unknown	Correlation	.517	.424	.631	.285
	Significance	.000	.000	.000	.000
	N	150	150	150	150
Change Unknown	Correlation	.182	.327	.457	.551
	Significance	.026	.000	.000	.000
	N	150	150	150	150
Result Unknown	Correlation	.652	.538	.448	.427
	Significance	.000	.000	.000	.000
	N	150	150	150	150

When Table 7 is analyzed, it is seen that there is a significant (p=.000) positive moderate relationship between the start unknown problems and the steps of understanding the problem (r=.517) and implementing the plan (r=.631). It was found that there was a significant (p=.000) positive and weak relationship between the initial unknown problems and the steps of making a plan (r=.424) and checking the solution (r=.285). It is seen that there is a significant (p=.000) positive and very weak relationship between problems with unknown change and the step of understanding the problem (r=.182). It was found that there was a significant (p=.000) positive and weak relationship between the steps of making a plan (r=.327) and executing the plan (r=.457). It is seen that there is a significant (p=.000) positive and weakly moderate relationship between the steps of checking the solution (r=.551) and problems with change unknown. It was found that there was a significant (p=.000) positive moderate relationship between problems with result unknown and the steps of understanding the problem (r=.652) and making a plan (r=.538). It is seen that there is a significant (p=.000) positive and weak relationship between problems with result unknown and the steps of executing the plan (r=.448) and checking the solution (r=.427).

Discussion and Conclusion

The research results, which examined the fourth-grade students' ability to solve four operation problems prepared according to the unknown situation and the problem-solving steps of these problems, were presented and discussed based on the findings obtained in the research.

The first result of the research:

- *According to the unknown situation, students were most successful in problems with unknown outcomes. This was followed by their success in problems with change unknown and start unknown. There are significant differences between the mean achievement scores of the students according to the unknown situation in the problems.*

The fact that the problems in which students were most successful were problems with unknown outcomes suggests that students encountered fewer problems with start unknown and change unknown in their classes. This is in parallel with the finding of Tertemiz, Özkan, Sural, and Akçakın (2015) that the problems based on four operations in primary school 1st-4th grade textbooks are mostly problems with unknown outcomes. Likewise, problems with start unknown are the least common problems in the textbooks. Bal and Dinç-Artut (2022) stated in one of their studies that students were generally successful in problems with result unknown. As in the present research, it is another situation in that students are successful in problems with change unknown and start unknown, respectively. Tarım (2017) examined students' ability to solve verbal problems based on addition and subtraction and the verbal problems they encountered in mathematics textbooks and found that students had more difficulty in addition and subtraction problems with start unknown and comparison problems than other types of problems. The researcher states that students encounter more problems with result unknown in textbooks. For this reason, the researcher suggests that it would be useful to give a balanced distribution of all kinds of problems in the course and workbooks. Temiz and Ev Çimen (2017) stated that students had the most problems solving problems with no solution and that they used the most time understanding the problem stage while solving these problems. The researchers stated that students with low academic achievement had difficulty understanding the problem step while solving problems with excessive and incomplete information. Like other studies, they also stated that different types of problems should be included in the curriculum, textbooks, and classroom practices. Similarly, Sarıbaş and Aktaş-Arnas (2016) stated that preschool students were more successful in problems with result unknown than change and start unknowns, depending on the type of unknown in the problem. Pilten (2010) also found that children were more successful in solving problems with result unknowns than problems with change and start unknowns.

The second major result of the research:

- *According to the problem-solving steps, students were most successful at understanding the problem. This was followed by making a plan, executing the plan, and checking the result, respectively. There are significant differences between the average achievement scores of the students according to the problem-solving steps.*

The first step in problem-solving is to understand what is being asked when the problem is read. In the present research, children were most successful in the step of understanding the problem; however, they maintained this success in the step of making a plan, albeit to a lesser extent, and did not maintain the same level of success in the steps of executing and checking the plan. However, considering that the highest score that can be obtained in each section of the test is five, it can be said that students also have problems understanding the problem step. When the related literature is examined, it is seen that there are studies that have similar findings to the findings obtained in the related research. For

example, Kuzu-İnci (2021) emphasized that first-grade students' performances in the steps of understanding the problem, making a plan, and executing the plan were generally low, and compared to the others, especially the students' success in the step of evaluating the solution was very low. Özdişçi and Katrancı (2020) examined the problem-solving and problem-posing skills of middle school students and stated that sixth, seventh, and eighth-grade students understood the problems, while fifth-grade students could not understand the problems. The researchers stated that the students were inadequate in the plan-making step and could not choose the strategy required for the solution. At the plan execution stage, the researchers noted that although the students reached the appropriate and correct solution, all the students had problems in problem-solving. In addition, the researchers stated that some of the eighth-grade students were able to evaluate the solution and students in all grades could not evaluate the solution of the problem. Sezgin-Memnun and İlksen-Kanbur (2020) stated that students with low reading comprehension levels had problems in all steps of the problem-solving process, while students with high reading comprehension levels were mostly successful in problem-solving steps. However, the researchers stated that students with high reading comprehension levels had problems in evaluating the solution from the problem-solving steps and posing problems. Dölek (2018) noted in the study that students' problem-solving skills were low and the number of students evaluating the solution was almost non-existent. Göktürk, Örnek, Hayat, and Soylu (2015) stated that students were not proficient in Polya's (1957) problem-solving steps of understanding the problem, preparing a plan, and evaluating the plan. In addition, the researchers stated that most of the students who correctly planned the solution to the problem had difficulties in the execution of the plan. Unlike these studies, Öztürk, Akkan, and Kaplan (2018) found that gifted students at different levels of education exhibited metacognitive skills in all problem-solving steps, trusted themselves in all problem-solving steps, reviewed the goals, and controlled themselves at each step. To summarize, there are similarities between the present findings and related studies. Students have difficulties in different steps of problem-solving, even in different grades. It can be said that having deficiencies in the first step causes difficulties to increase gradually in each step and this situation negatively affects the success of the students in the steps.

The third result of the research:

- *While there is a positive relationship between all variables (problems according to unknown situations and problem-solving steps), the relationships are at moderate and weak levels.*

When all the variables affecting problem-solving success are considered in general, it is significant that there is a positive relationship between them, even if it is small. Mentioned variables should also be emphasized to increase success in problem-solving. Tertemiz (1994) determined that the score obtained from the problem comprehension test, which includes the problem-solving steps among the factors that are considered effective in solving arithmetic problems, predicts problem-solving success at a high level. It was also found that children who were successful in problem-solving had high

problem comprehension scores. Özsoy (2002) found high positive correlations between the problem-solving achievement of all fifth-grade students at high, medium, and low levels in mathematics and the stages of understanding the problem, making a plan, executing the plan, and checking.

After all these results, it can be inferred that students should be compared with various types of problems prepared in different structures in textbooks or teachers' in-class activities. Silver, Ghousseini, Gosen, Charalambous, and Strawhun (2005) similarly highlighted the need to select problems that are prepared at different levels of difficulty and can be solved using different strategies. Özmen, Güven, and Taşkın (2012), in their study examining the types of problems used by mathematics teachers, stated that to increase students' problem-solving success, to associate the subjects with daily life and to look at the problems encountered from different perspectives, teachers should bring different types of problems in the classroom environment, such as visual, curriculum-independent, difficult, non-routine, missing and irrelevant data. Similarly, when the relevant literature is examined, many studies indicating that students should be compared with different types of problems that they need to solve using different strategies stand out (Akkan, Öztürk, Akkan, & Küçük-Demir, 2019; Temiz & Ev-Çimen, 2017; Tertemiz- Işık, Özkan, Çoban - Sural, & Ünlütürk-Akçakın, 2015; Toluk & Olkun, 2002).

The researchers developed some suggestions in line with the results obtained. The extent to which start unknown and change unknown problems are included in textbooks and in-class activities can be examined. Studies can be conducted to increase students' success in start unknown and change unknown problems. In textbooks and classroom practices, problem-solving steps can be given more importance as in Singapore mathematics examples (as cited in Bacakoğlu, 2022). Instead of many problems on one page, problems with fewer steps and different unknowns can be made more understandable with the schema strategy. Problem-solving skills should be viewed with a holistic perspective and the variables that have an impact should not be ignored.

Conflict of Interest

No potential conflict of interest was declared by the authors.

Credit Author Statement

Author 1: Conceptualisation, Methodology, Data collection, Analysis, Writing - Original draft preparation, Review & Editing

Author 2: Data analysis, Methodology, Writing - Review & Editing

Ethical Statement

This study was found appropriate in terms of research ethics by the decision of Gazi University Ethics Committee dated 02.11.2021 and numbered 247486.

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