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Investigation of primary school students solving arithmetic verbal problems

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ABSTRACT

The study determined the arithmetic verbal problem solving skills of primary school students and to examine them according to grade level and mathematics achievement variables. The study was designed according to the relational survey model, one of the quantitative research methods. The population of the research consists of students studying in public primary schools in the central districts of a large city in the south of Turkey. The sample consisted of 1,865 students determined according to the disproportionate stratified sampling method. The "arithmetic verbal problem test for students" prepared by the researchers was used as a data collection tool. As a result of the research, it was revealed that the students were most successful in the problems of combining and separating with “consequence unknown”, then “with change unknown” and “initial unknown”, but they were less successful in part-whole type problems. Thus, it was concluded that as the mathematics achievement and grade levels of the students increased, their success in solving verbal problems also increased.

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1. INTRODUCTION

Mathematics is one of the most important skills that a person must master in order to establish relationships between school practices and daily life practices, to manage life activities well, and to achieve economic success [1]–[4]. This study focuses on problem solving, which is at the center of mathematics teaching. Problems are difficult situations that the person has not encountered before and is unprepared for a solution. Dewey [5] defined the problem as anything that confuses the human mind, challenges it, and obscures belief. Kurlick and Rudnick [6] defined the problem as a quantitative or other situation in which the person cannot see or find a clear way to solve it. According to Bransford and Stein [7], the problem consists of inconsistencies between the initial state and the target state. When the definitions related to the problem are examined in general; situations that are new for the person, challenging the person, arousing the curiosity, and requiring the use of rules specific to a mathematics in the solution are discussed [8].

Problem solving is a rather vague concept that is thought of as an umbrella where different theoretical approaches coexist [9]. According to mathematicians, problem solving occurs when the algorithm to be applied is not obvious. Polya [10] identified some strategies for problem solving. In the first stage of problem solving, it is necessary to understand the problem and to see clearly what is necessary. In the second stage, determining the relationship between what is given in the problem and what is wanted and making a plan for the solution; implement the plan in the third phase; stated that it is necessary to reconsider the solution obtained in the fourth stage [10].

Problem solving forms the center of mathematics programs [11]. During problem solving activities, students can learn to solve a problem in a systematic way and to reveal how they think in this process. In addition, students discover new ways of thinking by solving problems, and all this helps them feel confident when faced with unfamiliar events in life. As their problem-solving skills improve, students' self-confidence increases and they learn to respect and value the ideas of others [12]. With problem solving, mathematical reasoning skills are developed, more meaningful learning is provided and strong bonds are formed between mathematical concepts [13]. Knowing the types, contents and purposes of use of the problems that should or have been dealt with in mathematics lessons is an important condition in the mathematics learning-teaching process.

Problems were classified differently by different researchers at different times. When the different problem classifications are considered collectively and primary school mathematics lessons are taken into account, it can be said that verbal problems based on four operation skills are frequently included in mathematics education, which aims to provide children with basic skills. Such problems are closed or routine verbal problems that can be solved with the help of four operations and have a single result [14], [15]. They are mathematical word problems based on four operations in elementary school 1-4 textbooks.

Mathematical word problems reflect the capacity and understanding of applying mathematical ideas in daily life and in the service of science, technology, engineering and advanced mathematics [16]. Solving word problems in mathematics often means extracting new information from given data. Known information may be collected by the solvent itself or provided by various means. To describe a real-world situation, the solver needs to select those aspects of the situation he or she wants to focus on and decide which objects should be explicitly stated [9]. Problem solving tasks, in this context, arithmetic and verbal problem solving tasks constitute an important part of the mathematics curriculum at primary school level. The most important reason for using such problems in schools is to teach students to apply the mathematical knowledge and skills they learned at school in the real world [4], [17]. On the other hand, problem solving opens a window to children's mathematical thinking. It provides opportunities for them to understand mathematics [18]. Stigler *et al.* [19] stated that studies have revealed that the semantic structure of the problem, the location of the unknown quantity, and how the problem is expressed are effective in solving a particular problem. Children's difficulties in solving verbal problems result from both developmental limitations and limited opportunities for learning and practice.

When the literature on problem solving is examined, it is seen that researchers [20], [21]. Van de Walle *et al.* [15] categorize arithmetic verbal problems in terms of the relationships they contain. According to this classification, combining (subcategories; outcome unknown, change unknown, initial unknown), separation (subcategories; outcome unknown, change unknown, initial unknown), comparison (subcategories; difference unknown, small unknown, large unknown) and fragment- It was analyzed in four main categories as part-whole (subcategories; whole unknown, part unknown).

In his book "How to Solve it", Polya [10] describes the act of problem solving as "Solving a big problem is a big discovery, but there is a bit of discovery in the solution of every problem. Even if your problem is not big, if it arouses your curiosity, offers you an opportunity to develop your creativity, and if you can solve it based on your own knowledge, you can experience the tension and enjoy the victory. This explanation reveals the importance he attaches to problem solving [10].

Curriculum changes that encourage students' in-depth understanding and emphasize the importance of thinking emphasize that problem solving is an important mechanism for developing these skills. However, problem solving is not a new curriculum or pedagogical innovation. More than 60 years ago, the importance of problem solving was recognized and this importance was strongly emphasized throughout the 1980s [22].

While national council of teachers of mathematics (NCTM) [23] emphasized that problem solving "should be central to the mathematics curriculum". In addition, NCTM [24] curricula are available to all students from pre-school to twelfth grade; It has been revealed that it is necessary to provide opportunities for creating new mathematical knowledge through problem solving, solving problems arising from mathematics and other content, applying and using the appropriate one of various strategies to solve problems, observing and thinking deeply on mathematical problem solving processes. The idea that problem solving should be a part of mathematics programs continued in the following years. In this context, NCTM [23] reiterated its call in 2003 for problem solving to form an integral part of the mathematics curriculum. However, there is little evidence to suggest that this focus on problem solving occurs in today's classrooms [25]–[27]. In this direction, it is thought that it is important to conduct new studies on problem solving at all levels.

In addition, problem solving makes an important contribution to the development of 21st century learning skills. Countries take 21st century learning skills into account when arranging their curricula. These skills were taken into account when creating curricula in Turkey. In order for children to be successful in solving verbal problem types, all verbal problem types should be adequately presented to children by teachers [28]–[34]. However, studies show that teachers mostly include problem types with unknown results when presenting verbal problems to children [28], [34], [35].

When the literature on arithmetic verbal problems is examined [36]–[43] studies are mostly carried out on preschool children. It has been observed that there are a limited number of studies at primary level within the framework of available resources. Olkun and Toluk [44] applied arithmetic verbal problems based on addition and subtraction on a total of 60 third and fourth grade students according to the relationships they contain. In this study, it was revealed that students were more successful in solving problems with more result unknowns. Tarım [34] applied arithmetic verbal problems based on addition, subtraction, multiplication and division to third graders according to the relationships they contain. The result of this research showed that more students are more successful in solving problems with result unknowns. Based on this fact, it is thought that determining the arithmetic verbal problem-solving skills of students studying at all levels of primary education based on addition, subtraction, multiplication and division will improve both their processing skills and their problem-solving skills. However, many studies on arithmetic verbal problems have been found in the relevant literature. Accordingly, determining the existing situation of primary school students on arithmetic-verbal problems is very important in terms of both classroom teachers, the organizers of the textbooks, and the experts who develop the education program in terms of their knowledge. In this context, answers to the following questions were sought: i) What are primary school students' achievement scores for arithmetic-verbal problems? ii) Is there a significant difference between grade levels and primary school students' scores in solving arithmetic verbal problems? iii) Is there a significant difference between the mathematics achievement levels of primary school students and the scores they get from arithmetic verbal problems?

2. RESEARCH METHOD

This study aimed to determine the arithmetic verbal problem solving skills of students attending all levels of primary school and to examine them according to some variables, was designed according to the relational survey model, one of the quantitative research methods. It is a survey that reveals the change between at least two variables according to the relational survey model. In this model, it aims to determine whether the variables examined change together and if there is a change [45]. In this study, it is tried to determine the change process between the arithmetic verbal problem solving skills of primary school students and their grade level and mathematics achievement.

2.1. Population and sample

The population of the research consists of students studying in public primary schools in the central districts of a large city in the south of Turkey. The sample consists of a total of 1,865 students determined according to the disproportionate stratified sampling method. In the disproportionate stratified sampling method, before selecting the sample, the universe is divided into various strata and random samples are selected from the divided plates [46]. In other words, in the disproportionate stratified sampling process, only the number of strata is considered and the proportions of these strata within the universe are not taken into account. Within the scope of this study, the universe is divided into three layers according to the socio-economic status of the regions where the schools are located. The number of students studying in these schools varies by region. Accordingly, the student information included in the study is given in Table 1.

Table 1. Distribution of personal characteristics of the students in the sample group

Personal traits	Variables	F	%
Gender	Female	925	49.6
	Male	940	50.4
	Total	**1,865**	**100**
Grade level	First class	466	23.6
	Second class	480	25.7
	Third class	462	25.9
	Fourth class	457	24.5
	Total	**1,865**	**100**
Mathematics achievement levels	Should be improved	673	36.1
	Good	668	35.8
	Very good	524	28.1
	Total	**1,865**	**100**
School's socio-economic level (SEL)	Lower SEL	689	38.0
	Medium SEL	672	36.0
	Upper SEL	504	27.0
	Total	**1,865**	**100**

Table 1 shows that the distribution of the students in the sample group according to the variables of gender, grade level, mathematics achievement level and socio-economic level of the school is presented. Accordingly, 49.6% of the students participating in the study were female and 50.4% were male students. 23.6% of the students attend the first grade, 25.7% attend the second grade, 25.9% attend the third grade and 24.5% attend the fourth grade. On the other hand, when the mathematics achievement levels are examined, 36.1% of the students should be improved, 35.8% are at the level of "good" and 28.1% are at the level of "very good". In addition, when the socio-economic level of the schools where the students participating in the sample are studied, 35.9% of the students are educated in schools in the lower SEL, 36% in the middle SEL and 28% in the upper SEL.

2.2. Data collection tool

As a data collection tool in the study, a draft "Arithmetic Verbal Problem Test for Students" was created by the researchers to determine the arithmetic verbal problem solving skills of primary school students. Whether the problems in the draft form are suitable for primary school students were presented to the opinions of five classroom teachers and two lecturers who are experts in mathematics education problem solving. The test was given its final form in line with the feedback received from them. The prepared test was arranged according to the classification of arithmetic verbal problems for addition-subtraction-multiplication-division [15]. Accordingly, arithmetic verbal problems are classified as combining, separating, part-part-whole and comparison problems. According to this classification, combining (subcategories; outcome unknown, change unknown, initial unknown), separation (subcategories; outcome unknown, change unknown, initial unknown), comparison (subcategories; difference unknown. small unknown. large unknown) and part, part-whole (sub-categories; whole unknown, part unknown) were examined in four main categories. The data collection tool consists of 11 questions, one from each category.

2.3. Data collection

School administrators and teachers were interviewed by contacting the schools where the application would be made. In these interviews, the purpose of the study was explained and the necessary permissions were obtained from the parents of the students and the implementation process was started. In the application of the arithmetic verbal problem test for the students, the necessary information was given to the classroom teachers and the forms were filled in one lesson. In addition, information about the general success of the students in the mathematics lesson was obtained from the classroom teachers.

2.4. Analysis of data

The questions in the arithmetic verbal problem form for students were examined one by one by two researchers. Students' solutions were evaluated as 1 point if they were correct, and 0 points if they were incorrect or unanswered. In the analysis of the obtained data, descriptive statistics and multivariate analysis of variance (MANOVA) analyzes were applied with the help of SPSS 22.0 program. Before the analysis of the data, Shapiro Wilks, Box's M test and Levene test were performed on the data and it was concluded that the data were suitable for the parametric test conditions [47].

3. RESULTS

This study conducted to determine the arithmetic-verbal problem solving skills of primary school students. It examined the relationships between these skills and their grade level and mathematics achievemen. Table 2 presents the distribution of students' scores in solving arithmetic-verbal problems.

Table 2. Distribution of primary school students' achievement scores for arithmetic verbal problems

Arithmetic verbal problem type	Category	f	Mean	**Ss**
Join	Result unknown	1865	.90	.23
	Change unknown	1865	.68	.41
	Initial unknown	1865	.69	.41
Separation	Result unknown	1865	.79	.35
	Change unknown	1865	.69	.41
	Initial unknown	1865	.60	.40
Comparison	Difference unknown	1865	.61	.44
	Little unknown	1865	.58	.44
	Big unknown	1865	.55	.45
Part-whole	All unknown	1865	.54	.47
	Part unknown	1865	.40	.45

Table 2 reveals that the students are successful in solving problems in the join. This is followed by problems of separation (subtraction), comparison (multiplication) and part-whole (division). According to Table 2, when the results related to the sub-categories of each problem type are examined, it is seen that the combination type problems are successful in the problems with “consequence unknown”, and “change unknown” and “initial unknown” (X=69). Type problems are seen to be less successful. On the other hand, it is seen that students are most successful in separation-type problems with "result unknown" (X=79), then "change unknown" (X=69) and "initial unknown" (X=60) types of problems. In addition, in comparison type verbal problems, it was found that the students were close to each other and moderately successful in "difference unknown" (X=61), "small unknown" (X=58) and "large unknown" (X=55) types of problems. Finally, in part-whole type problems, students were less successful in "whole unknown" (X=54) and "part unknown" (X=40) types of problems.

As the second sub-objective of the study, the scores obtained by the students in solving arithmetic verbal problems according to their grade levels were analyzed and the results are given in Table 3 (see Appendix). The table shows the distribution of students' achievement scores in solving verbal problems according to grade levels. According to the grade level, the scores of the students in solving the verbal problems show a significant difference in all categories except the big unknown category (F=1.48; p>0.05). According to the results of the analysis applied to determine the direction of the difference, it is seen that the students studying in the upper classes are more successful than other students. It can be said that as the grade level of the students increases, their success in solving verbal problems increases. Based on to the last sub-purpose of the study, the scores obtained by the students in solving arithmetic verbal problems were analyzed referring to their mathematics achievement levels and the results are given in Table 4.

Table 4. Analysis results of students' scores in solving arithmetic verbal problems according to mathematics achievement levels

Arithmetic verbal problem type	Category	Mathematics achievement levels	N	X	ss	sd	F	p	Eta square	Significant difference
Join	Result unknown	Should be improved	673	.82	.31	2	63.342	.00	0.65	3.2>1
		Good	668	.94	.17					
		Very good	524	.95	.14					
	Change unknown	Should be improved	673	.44	.44	2	237.957	.00	.20	3>1.2 2>1
		Good	668	.78	.35					
		Very good	524	.87	.29					
	Initial unknown	Should be improved	673	.45	.44	2	211.126	.00	.18	3>1.2 2>1
		Good	668	.78	.36					
		Very good	524	.87	.28					
Separation	Result unknown	Should be improved	673	.62	.41	2	155.651	.00	.14	3>1.2 2>1
		Good	668	.85	.28					
		Very good	524	.93	.20					
	Change unknown	Should be improved	673	.52	.44	2	94.195	.00	.09	3>1 2>1
		Good	668	.76	.36					
		Very good	524	.80	.35					
	Initial unknown	Should be improved	673	.49	.39	2	45.667	.00	.04	3>1.2 2>1
		Good	668	.62	.39					
		Very good	524	.71	.39					
Comparison	Difference unknown	Should be improved	673	.41	.44	2	50.128	.00	.05	3.2>1
		Good	668	.60	.44					
		Very good	524	.65	.44					
	Little unknown	Should be improved	673	.47	.43	2	37.467	.00	.03	3.2>1
		Good	668	.64	.43					
		Very good	524	.66	.44					
	Big unknown	Should be improved	673	.55	.43	2	10.969	.00	.01	3.2>1
		Good	668	.65	.43					
		Very good	524	.65	.44					
Part-whole	All unknown	Should be improved	673	.52	.46	2	1.429	.24	.00	
		Good	668	.57	.46					
		Very good	524	.53	.48					
	Part unknown	Should be improved	673	.33	.42	2	14.02	.00	.02	3.2>1
		Good	668	.43	.46					
		Very good	524	.46	.47					

Table 4 shows the distribution of students' achievement scores in solving verbal problems according to their mathematics achievement levels. According to this, the scores that students get in solving verbal problems according to their mathematics achievement levels show a significant difference in all categories except for the "whole unknown" category (F=1.429; p>0.05) in the part-whole type. According to the results of the analysis applied to determine the direction of the difference, it is seen that students with very good and good success are more successful than students at the level of improvement. Accordingly, it can be said that as students' mathematics achievement increases, their success in solving verbal problems also increases.

4. DISCUSSION

As a result of this study, which was carried out with the aim of determining the arithmetic verbal problem solving skills of students attending all levels of primary school based on addition, subtraction, multiplication and division and examining them according to some variables, it has been revealed that students' success in combining and separating problems is higher than in comparison and part-whole problems. One reason may be that the operations for comparison and part-whole problems are more complex than joining and separation. In comparison problems, the operation structure also includes the addition operation. Similarly, the operation structure of part-whole problems includes subtraction and multiplication operations. It can be thought that this situation may have caused students to be less successful in solving problems based on such operations [33], [44].

When each problem type is considered in terms of sub-categories, it has been seen that students are most successful in combining and separating problems with "result unknown", then "change unknown" and "initial unknown" problems. In addition to this, it was concluded that the students were successful at least in "part unknown" ($\bar{X}$=40) type problems in part-whole problems. When the relevant literature is examined, it is seen that there are similar results to the results of this research [31], [32], [48], [49]. For example, in the study of Sarıbaş and Aktaş-Arnas [32] in which they examined 57 mathematical activity books containing verbal problems related to addition and subtraction, the majority of the activity books only include problem examples with unknown results. Of these problems, 84.2% of them are combining-result unknowns and 78.9% separation-result unknowns. The reason why the students in this study achieved more success in the sub-category of unknown results may be similar.

According to the second sub-goal of the study, it was concluded that as the grade levels of the students increased, their success in solving verbal problems also increased. As students' grade levels increase, naturally, their experience of mathematics and their knowledge and practices in this context also increase. From this, it can be said that the grade level supports the positive increase in success in solving such problems. On the other hand, it was concluded that as the mathematics achievement of the students increased, their success in solving verbal problems also increased [50]–[53]. For example, in the study of Yeşilova [53], it was concluded that students with good mathematics achievement had higher problem-solving success than other students, they used different strategies more, and their solutions were more detailed and understandable. From this point of view, it can be said that the results obtained from this study are in parallel with the literature findings. Students who are more successful in mathematics can show a higher performance in solving verbal problems than other students.

5. CONCLUSION

These results revealed that the students were most successful in the problems of combining and separating with "consequence unknown", then in "change unknown" and "initial unknown" problems, but they were less successful in part-whole type problems. On the other hand, it was concluded that as the mathematics achievement and grade levels of the students increased, their success in solving verbal problems also increased. When these results are taken together, not all verbal problems are included in the textbooks with the same frequency. It can be thought that the fact that the sub-categories of each of these problem types has different operation structures and complexity levels affects the success of students in solving these problems.

In addition, it can be said that grade level and mathematics achievement also affect success in all problem types discussed in this research. The study is limited only to primary school students' arithmetic verbal problem solving skills related to addition and subtraction. In another study, classroom teachers or mathematics teachers' in-class practices or awareness levels on verbal problem types can be examined.

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APPENDIX

Table 3. Analysis results of students' scores in solving arithmetic verbal problems according to grade levels

Arithmetic verbal problem type	Category	Class (n=466)		Class (n=480)		Class (n=462)		Class (n=457)	
		X	**ss**	**X**	**ss**	**X**	**ss**	**X**	**ss**
Join	Result unknown	.82	.31	.92	.21	.93	.17	.93	.20
	Change unknown	.47	.43	.58	.44	.82	.33	.85	.31
	Initial unknown	.46	.44	.63	.42	.84	.31	.81	.34
Separation	Result unknown	.66	.41	.75	.37	.89	.26	.85	.292
	Change unknown	.48	.41	.65	.43	.78	.36	.82	.34
	Initial unknown	.52	.42	.56	.38	.62	.41	.69	.37
Comparison	Difference unknown	.45	.44	.47	.46	.62	.44	.66	.43
	Little unknown	.52	.45	.52	.44	.61	.45	.68	.42
	Big unknown	.62	.42	.60	.45	.59	.44	.65	.43
Part-whole	All unknown	.40	.45	.57	.45	.59	.47	.61	.46
	Part unknown	.28	.42	.42	.44	.41	.46	.50	.47

Table 3. Analysis results of students' scores in solving arithmetic verbal problems according to grade levels (*Continued*)

Arithmetic verbal problem type	Category	sd	F	p	Eta square	Significant difference
Join	Result unknown	3	26.96	.00	.04	2>1 3.4>2
	Change unknown	3	106.48	.00	.15	3.4>1.2
	Initial unknown	3	94.0	.00	.13	4.3>1.2 2>1
Separation	Result unknown	3	43.57	.00	.07	4.3.2>1 4>3.2 3>2
	Change unknown	3	71.29	.00	.10	4.3>1.2 2>1
	Initial unknown	3	16.58	.00	.03	4>1.2.3 3>1.2 2>1
Comparison	Difference unknown	3	26.08	.00	.04	4.3>1.2 3>1.2 2>1
	Little unknown	3	13.91	.00	.02	4>1.2.3 3>1.2
	Big unknown	3	1.48	.217	.00	
Part-whole	All unknown	3	19.69	.00	.03	4.3>2 2>1.
	Part unknown	3	19.46	.00	.03	4>1.2.3 3>2 2>1

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