IOJPE

ISSN: 1300 – 915X
www.iojpe.org

International Online Journal of Primary Education 2021, volume 10, issue 2

THE EFFECT OF WORKED EXAMPLES METHOD ON PRIMARY SCHOOL STUDENTS' FRACTIONS ACHIEVEMENT

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Received: November 25, 2020 **Accepted:** June 09, 2021 **Published:** December 31, 2021

Suggested Citation:
Ayvaz Can, A. (2021). The effect of worked examples method on primary school students' fractions achievement. *International Online Journal of Primary Education (IOJPE), 10*(2), 361-382.

Abstract

Examining the effect primary school teachers' preferred teaching method has on primary school students' mathematics achievement is important. In this context, the purpose of the research is to determine whether the worked example method is effective on students' ability to learn fundamental knowledge about fractions and their success in solving mid- and high-difficulty fraction problems compared to the traditional teaching method. The research uses the experimental design with a pretest-posttest control group. The experimental group has 36 students, and the control group has 37 students. While teaching fractions was conducted in accordance with the traditional teaching method in the control group, the worked example method was applied in the experimental group. The research results from the research determined the worked example method to be more effective than the traditional teaching method in learning the fundamental knowledge about fractions and developing student success in solving mid- and high-difficulty fraction problems. The traditional teaching method was not effective at developing students' success in solving high-difficulty fraction problems. Because problem solving is a skill that develops slowly, teachers should not prefer time-consuming methods in developing problem-solving skills. Using the worked example method is suggested in primary school as it has been revealed to develop problem-solving skills in a short time and these skills' foundations are laid in primary school.

Keywords: Primary school, mathematics, worked example method, fraction, problem solving.

INTRODUCTION

Mathematics is perceived as a difficult lesson to learn all over the world. As in all levels of education, primary school students also have difficulty in mathematics classes. This situation is one of the main problems of education systems in the world. Students' knowledge and skills as well as successes and failures in the last year of primary school are a result of their own work performances as well as their primary school teachers' during primary school. Student success in learning mathematics is affected by the way their primary school teacher teaches it.

Teachers teach how they perceive their role (Olkun & Toluk Uçar, 2014). Most teachers prefer traditional classroom practices over constructivist ones. Teachers use narration and question-answer methods to convey information instead of using appropriate methods to enable students to create knowledge (Khan, Mehmood, & Jumani, 2020; Rosenthal, 1995; Venkateswarlu & Kumar, 2020). Research results in the literature also show that teachers continue to use traditional methods in mathematics classes (Behlol, Akbar, & Sehrish, 2018; Lessani, Yunus, & Bakar, 2017; Nafees, 2011). In addition, most teachers have a table listing traditional problem-solving steps in their classroom (Glover, 2019). For this reason, studies that comparatively demonstrate the effectiveness of traditional teaching methods and different teaching methods are still current (Arise, 2018; Ardeleanu, 2019; Lessani, Yunus, & Bakar, 2017; Mutrofin, Degeng, Ardhana, & Stegosauri, 2019; Nurutdinova et al., 2016; Saira & Hafeez, 2021; Seeley, 2017).

The traditional method is one in which students are passive (Zhao & Li, 2020) and the teacher conveys information to the students (Gholami et al., 2016). The traditional method is teacher-centered, and this method of teaching in is the predominant case (Lessani, Yunus, & Bakar, 2017). A teacher using the traditional method in mathematics class performs the following steps in turn (Stonewater, 2005):

- Teacher review of previous assignments
- Teacher's demonstration of low-lewel problem solutions.
- Assigning homework that can be solved by imitating what the teacher shows and does not require the supervision of the teacher, which the students can do in their own turn.

Samuelsson (2008) defined the traditional method used in his research as follows: The teacher explains the process and strategy on the board at the beginning of the lesson. Afterwards, students practice by solving the questions in the textbook. Within the scope of this research, the traditional method is expressed as one that mostly uses narration and question-answer methods together. In addition, the teacher presents the students with verbal expressions of knowledge and principles in the traditional method, in which the means-ends analysis is used in teaching problem solving. These methods do not help develop students' mathematical thinking (Boaler & Brodie, 2004; Jina, 2007). On the contrary, they prevent student participation and thinking (Brodie, 2007). These teacher-preferred methods cause students to experience failure in mathematics as well as to dislike and fear mathematics. As a result, the traditional teaching method is insufficient at providing students with complex cognitive competencies in mathematics classes. For this reason, new teaching methods have been investigated that will be effective in developing students' thinking and problem-solving competencies in all education levels from primary school to university. New teaching methods require processes in which students are more participatory and active, constantly studying or practicing (Compañ-Rosique, Molina-Carmona, & Satorre-Cuerda, 2020). Experts have developed many new learning methods to facilitate the mathematics-learning process in mathematics education (Lesnussa, 2019). One of these methods is the worked examples method, which has been shown as an alternative to learning through problem solving (Van Gog, Rummel, & Renkl, 2019). The effects of this method on student achievement in mathematics have been investigated for many years and are still being investigated (Corral, Quilici, & Rutchick, 2020; Nainan, Balakrishnan, & Mohamad Ali, 2020; Rodiawati & Retnowati, 2019; Yeo & Fazio, 2019; Yeo & Tzeng, 2020).

Studies on the worked examples method focus on mathematical problem-solving processes, and this method has proven to be effective in teaching problem solving (Baars, van Gog, de Bruin, & Paas, 2017; Gupta, & Zheng, 2020; Hoogerheide, Renkl, Fiorella, Paas, & van Gog, 2019; Widyastuti & Retnowati, 2021). Mathematical problem solving is a new attempt (Krulik & Reys, 1980), an intuitive process (Polya, 1945), and a model-generating activity (Lesh & Zawojewski, 2007). Solving math problems activates mental thinking and contributes to the mental development of the individual (Goffin & Tull, 1985). While people with advanced problem solving skills use information effectively, people who have not developed problem-solving skills only carry information (Altun, 2005). Understanding mathematical knowledge and establishing relationship between this information occur in the problem-solving process, which is at the center of mathematics curriculum (Jitendra, Griffin, Buchman, & Sczesniak, 2007). Problem solving has been the subject of many studies due to its importance (Karasel, Ayda & Tezer, 2010; Nguyen, Guo, Stamper, & McLaren, 2020). Based on the results from these studies, researchers have stated students to often have problems in transferring the knowledge and skills they learned in mathematics to new situations or problems and teaching methods to be needed to solve this problem (Van Gog, Paas, & Van Merriënboer, 2004). The reason for this is that the purpose of teaching is to provide students with knowledge and skills and to prepare them to transfer these knowledge and skills to different environments (Nelson, 2006). The reason why students cannot transfer information in mathematics is shown to be that students tend to solve problems without understanding the problem's underlying principles (Catrambone, 1996; Van Gog, Pass & Van Merriënboer, 2004). Primary school students, especially those who lack the cognitive structures known as schema, need an expert model that reveals the principles related to the problem, that relates these principles and states their role in problem solving, and that shows the implementation processes step by step. In the worked example method, students are provided with the teaching support (scaffolding) they need by presenting the expert model.

Within this scope, the research discusses the teaching of fractions, which is one of the subjects that students need the most teaching support with following natural numbers in primary school. Many reasons exist for limiting the research to the topic of fractions. One of the reasons is that the subject of fractions is an important and fundamental subject in all grades of primary school that progresses cumulatively and is connected with other mathematical topics such as algebraic operations, ratios, proportions, decimal numbers, and percentage calculations (Ayvaz Can & Türer, 2018; Van de Walle, Karp & Bay-Williams, 2019). Another reason is that students make more mistakes and have more misconceptions about fractions (Van Hoof, Engelen, & Van Dooren, 2021). For example, the students find the result of $\frac{2}{4}+\frac{6}{8}$ as $\frac{8}{12}$ by treating the numerator and denominator as if they are natural numbers. These failures are a part of the student's process of transforming and transferring information (DeBlois, 1995). These mistakes made by students are quite common (Behr, Wachsmuth, & Post, 1985; Booker, 1998; Carraher & Schliemann, 1991; D'Ambrosio & Mewborn, 1994; Davis, 2003; Keijzer & Terwel, 2003; Leinhardt & Smith, 1985; Newstead & Murray, 1998; Oliveira & Ramalho, 1994; Orton & Frobisher, 1996). Teaching fractions is one of the most difficult math subjects for teachers and learning for students. For this reason, it is extremely important for the teacher to use appropriate methods in eliminating the difficulties and failures experienced in the learning and teaching process (Kyriakides, 2006; Ma, 2010; Petit & Zawojewski, 1997). The need exists for methods that will guide teachers and enable students to learn effectively and meaningfully without misconceptions about the subject of fractions in which learning and teaching difficulties have increased remarkably. Studies in the literature (Bokosmaty, Sweller, & Kalyuga, 2015; Lockwood, Ellis, & Lynch, 2016; Pachman, Sweller & Kalyuga, 2014; Sweller, 2011) have shown the worked example method to meet this need. Therefore, usefulness is found in having primary school teachers know and apply this method.

Theoretical Underpinnings

Learning through worked examples has received much attention recently, but the concept of learning by example is nothing new. From the mid-1950s to the 1970s, cognitive and educational psychologists benefited from the paradigm of learning-by-example related strategies for studing and defining the processes of concept learning (Atkinson, Derry, Renkl, & Wortham, 2000; Bruner, Goodnow, & Austin, 1956; Bourne, Goldstein, & Link, 1964; Tennyson, Wooley, & Merrill, 1972). Educational psychologists have focused specifically on educational practices that demonstrate how to select, present, and arrange examples (Tennyson & Cocchiarella, 1986). In the 1950s, Miller conducted his first studies on the cognitive load theory, which was effective in the emergence of worked examples. Miller stated the limits of the capacity of working memory. While identifying ways to facilitate concept learning was focused upon until the 1970s, some researchers focused on more complex forms of knowledge and learning after the 1970s (Brewer & Nakamura, 1984). At that time, researchers who investigated the cognitive load theory focused on the concept of schema and often used it to reveal the performance differences between experts and novices (Chi, Feltovich, & Glaser, 1981; Chi, Glaser, & Rees, 1982; Hinsley, Hayes, & Simon, 1977; Rumelhart & Ortony, 1977; Silver & Marshall, 1990; Silver, 1979; Van Lehn, 1990). In light of these developments, Sweller conducted detailed studies on how the brain processes and stores information within the scope of cognitive load theory. Sweller planned these studies in particular on students taking mathematics problem-solving instruction.

Sweller and other researchers have continued to test the cognitive load theory over the years, focusing on explaining how worked example should be designed to encourage efficient learning in teaching environments (Darabi, Nelson, & Paas, 2007; Paas & Van Merriënboer, 1994; Sweller, 2006; Van Merriënboer & Sweller, 2005). The first studies on worked examples were carried out under controlled laboratory conditions. The findings showed the worked examples approach to be able to applied effectively on larger scales and under everyday classroom conditions (Sweller, Ayres, & Kalyuga, 2011). The first studies on the use of worked examples in teaching were conducted in the field of mathematics. Sweller and Cooper (1985) investigated worked example in algebra. They found the failure rate of students in the experimental group in which the worked example had been used to be lower compared to the students in the control group. The students in the experimental group were also found to be faster at problem solving. Examining the effects worked examples have in mathematics has become the focus for many researchers (Brooks, 2009; Carroll, 1994; Chen, Retnowati, & Kalyuga, 2020; Corral, Quilici, & Rutchick, 2020; Faulkner, 1999; İltüzer, 2016; Özcan, Kılıç, & Obalar, 2018; Pass, 1992; Pease, 2012; Pillay, 1994; Paas & Van Merriënboer, 1994; Rodiawati & Retnowati, 2019; Sweller, 2020; Sweller & Cooper, 1987).

The Worked Examples Method

The worked examples method is the teaching method preferred by cognitive load theorists and is used by teachers to reduce students' cognitive load in complex learning tasks. Worked examples are the tools of this method (Morrison & Anglin, 2005; Van Gog & Rummel, 2010). A worked example is a step-by-step example of how to solve a problem or perform a task (Clark & Mayer, 2011; Clark, Nguyen, & Sweller, 2006; Da Costa & Seok, 2010; Renkl, 2002, Sweller, Ayres & Kalyuga, 2011) and consists of three elements; the problem, solution steps, and the final result (Renkl & Atkinson, 2003; Renkl, 1997; Renkl, 2005). Worked examples typically have a structure that shows a problem, a goal, and solution steps. It allows the goal to be reached from the problem (Van Gog, Paas, & Van Merriënboer, 2004). For this reason, the learner focuses only on the problem and the solution steps they will use to solve the problem while learning with worked example. This process significantly reduces the amount of load on working memory and facilitates learning (Kalyuga, 2008).

In the worked examples method, one or more principles related to the relevant field are given first. Later, students are presented with several sufficient examples (Renkl & Atkinson, 2010). In the worked examples method, the proper steps to solving problems are presented in predetermined problem categories (Faulkner, 1999). In this way, students have the necessary solution steps for solving problem (Brooks & Crippen, 2005). Worked example can be categorized as completion and full-worked examples. Completion examples provide partial solution steps, and students are expected to solve the rest of the problem based on the partial solution. Unlike the completion example, the full-worked example shows all steps of the problem solving process (Gupta & Zheng, 2020).

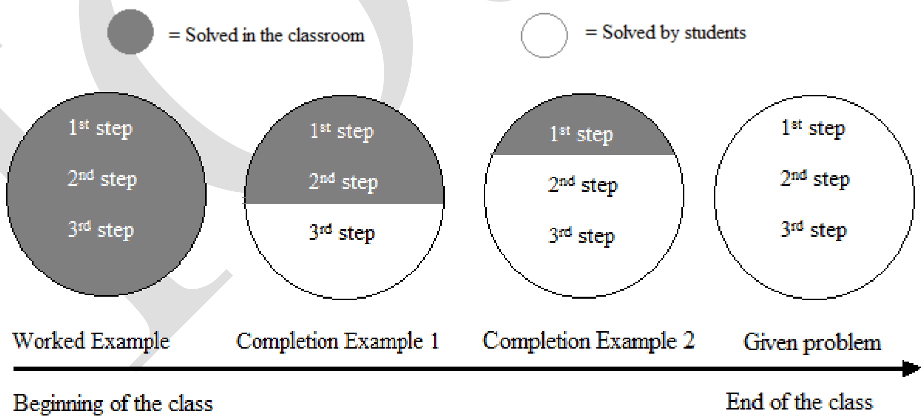

Figure 1. Transition from worked examples to problems (Clark, Nguyen, & Sweller, 2006)

Assuming the teaching of a probability calculation, it is first started with the worked example presented with all sides, represented by the gray circle on the left. Then it is passed to a second example where the last step is not done. This example matches the second circle in Figure 1. The first two steps are explained to the students, and the last step is left for the students to complete. At the end, students are asked a probability problem as an exercise problem to work out on they own. This

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ISSN: 1300 – 915X
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International Online Journal of Primary Education 2021, volume 10, issue 2

situation matches the rightmost circle. In this process, students gradually perform an increasing mental process (Clark & Mayer, 2011).

Worked Examples in Mathematics

Until the 1960s, traditional problem-solving strategies had been widely applied in educational settings in mathematics problem-solving teaching (Tuovinen, 1997). While solving a mathematical problem, an individual goes through many complex cognitive processes such as understanding the problem clause, choosing the necessary data for the solution, solving the problem, and deciding whether the answer is logical (Charles, 1985). Cognitive load theorists who study problem-solving processes have criticized the use of problem-solving strategies commonly used in problem solving teaching (Ashman, Kalyuga, & Sweller, 2020; Darabi, Sikorski, Nelson, & Palanki, 2006; Sweller, 2006; Sweller, Ayres, & Kalyuga, 2011). In the traditional approach, teachers use means-ends analyses (determining what is given and asked). Determining what is given and asked in the traditional approach means deciding what the problem is and what to do. Experienced problem solvers immediately identify what is given and asked in the problem, namely the means and the ends that will lead to the goal. Novice problem solvers may focus on unnecessary details (Senemoğlu, 2020). Therefore, working memory can be overloaded due to its limited capacity. Conducting studies to minimize cognitive load, Sweller adapted worked examples onto the mathematics problem-solving teaching process. Sweller argued that students who study using worked examples learn better. Sweller attributed this to the minimization of cognitive load.

According to the cognitive load theory, the use of traditional problem-solving strategies requires especially inexperienced students to make a significant amount of mental effort in the process of problem solving (Paas & Van Merriënboer, 1994; Paas, Renkl, & Sweller, 2004; Sweller, 1988; Van Gog, Paas & Van Merriënboer, 2004). For this reason, the working memory is easily overloaded during teaching activities, especially in the early stages of learning when students' capacity is limited (Clarke, Ayres, & Sweller, 2005; Sweller, 1988). Cognitive load theory emphasizes that the load that occurs on the working memory should be brought under control in order to realize efficient learning (Sweller, 2006; Van Merriënboer & Sweller, 2005). The cognitive processes in the learning process with respect to this theory are given in Figure 2.

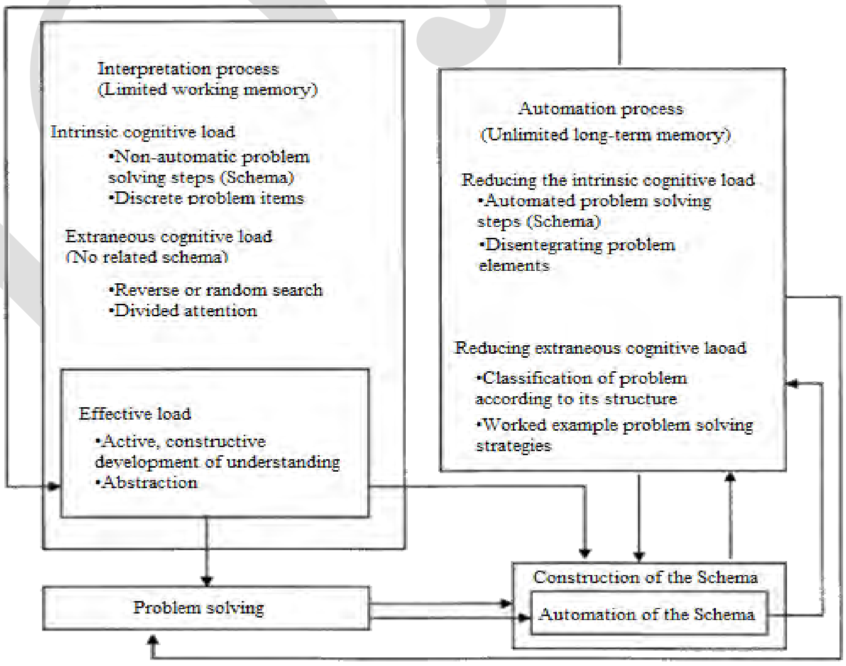

Figure 2. The learning process (Brooks, 2009)

When examining the Figure 2, cognitive loads in the learning process are seen to occur in the working memory, which has a limited capacity. When this burden is not brought under control, the development of schemata is prevented; automation cannot be realized and slow learning occurs as a result (Brooks, 2009). For this reason, traditional problem-solving teaching is ineffective on inexperienced students who have not yet acquired a comprehensive cognitive schema (Sweller, 1988).

Researchers studying the cognitive load theory have focused on the concept/schema construction process. Researchers have argued one of the ways to positively use the relationship between cognitive loads in short-term memory in the learning process to be to use worked examples in the learning process (Hollender, Hofmann, Deneke, & Schmitz, 2010). The worked example used in problem-solving teaching and the processes of traditional problem-solving approach are given in Figure 3.

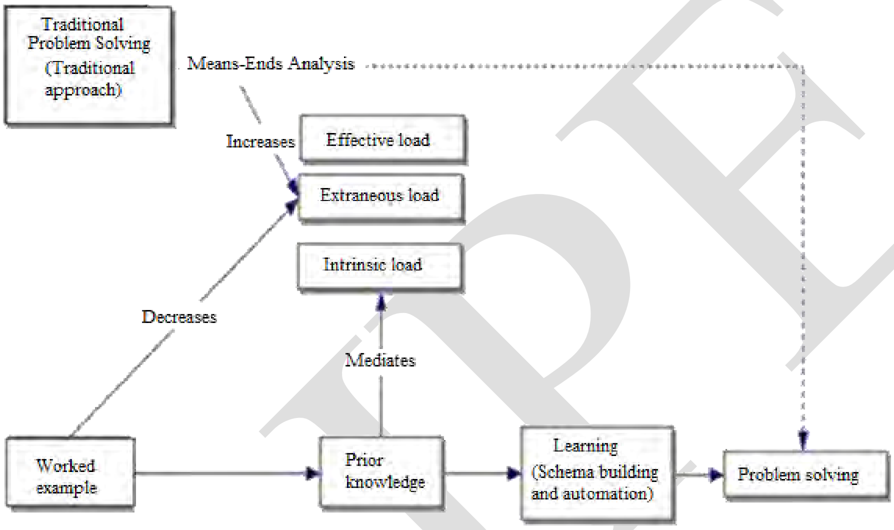

Figure 3. Worked example in learning (Brooks, 2009)

In traditional problem solving approach, means-ends analysis is used. Means-ends analysis enables to determine what is given and what is desired, what the problem is and what should be done (Senemoğlu, 2020). Experienced problem solvers immediately identify what is desired and given in the problem, namely the purpose and the means that will lead to the goal. Novice problem solvers can focus on unnecessary details (Senemoğlu, 2020). This situation causes an increase in extraneous load in working memory (Sweller, 1988). Because of the limited working memory, means-ends analysis has been criticized by cognitive load theorists (Sweller & Levine, 1982). In other words, cognitive load theorists criticized the use of problem solving strategies in the educational environment (means-ends analysis) (Darabi, Sikorski, Nelson, & Palanki, 2006). Cognitive load theorists have stated that even though general strategies such as means-ends analysis are effective problem-solving strategies, they are not suitable for the limited capacity of working memory and this technique is insufficient in creating schema (Sweller, 1998).

According to cognitive load theorists, working primarily with worked example in problem-solving teaching provides student with an analogy while solving the problem. When moving to problem solving without using an analogous example, most of the capacity of working memory is used to find the best solution strategy. Very little of it is used for schema construction (Clark, Nguyen, & Sweller, 2006). Rather than focusing on goals or sub-goals with worked example, the learner's attention focuses on the problem situation and operations. This way forms effective structures between cognitive schemata and helps form methodological skills (Clark & Mayer, 2011; Van Gerven, Paas, Van Merriënboer, & Schmidt, 2002). Subsequently, extraneous cognitive loads are reduced by transitioning to exercises that help consolidate and automate new information through worked examples, as seen in Figure 3 (Clark & Mayer, 2011). Thus, efficient use of cognitive capacity is ensured in the learning process. To sum up, the worked example method is an important pedagogical method that can be used in the formation of schemata that support problem-solving skills and in providing faster learning (Abdul-Rahman & Du Boulay, 2014).

The Use of Worked Examples in Primary School

The worked examples method helps novice students in particular who do not have much experience in problem solving. Novice students are defined as students who lack the cognitive structures (schema) for learning new information. The needs of novice students should be met with well-structured target-oriented educational approaches (Jones, 2014). The worked examples method provides well-structured training. In addition, many studies have found that young children need more teaching support than adults for completing a difficult task (Hsin & Wu, 2011; Wood, Bruner, & Ross, 1976). For this reason, Hsin and Wu (2011) recommend that educators provide more scaffolding for young children to help them achieve cognitive goals. With the worked examples method, children of primary school age can be provided with the scaffolding they need.

When examining the results from the studies in the literature, the worked examples method provides the scaffolding needed by novice primary school students who do not have enough experience and lack cognitive structures. Therefore, the effects of this method on mathematics lessons at the primary school level and should be examined.

Research Hypothesis

The aim of this research is to reveal whether the teaching method used by primary school teachers in mathematics lessons has an effect on primary school students' mathematics achievement. In this context,

The mathematics achievement of students who learn mathematics with the worked examples method is different from those who learn according to traditional teaching methods.

To test this hypothesis, the following sub-hypotheses are developed and tested.

Sub-Hypothesis 1: The worked examples method effects the development of primary school 4^{th}-grade students' achievement in learning fundamental knowledge about fractions and solving mid- and high-difficulty fraction problems.

Sub-Hypothesis 2: The traditional teaching method effects the development of primary school 4^{th} grade students' achievement in learning fundamental knowledge about fractions and solving mid- and high-difficulty fraction problems.

Sub-Hypothesis 3: The effects of the worked examples method and the traditional teaching method differ from each other in how primary school 4^{th}-grade students' learn fundamental knowledge about fractions and how they develop success in solving mid- and high-difficulty fraction problems.

METHOD

Research Model

A pretest–posttest quasi-experimental design was used in the current study. This design is the best way to explain the cause-effect relationships between variables (Fraenkel & Wallen, 2009). The design of the study are indicated in Table 1.

Table 1. The design of the study with the assessment instruments

Group	Pretest	Procedure	Posttest
Experimental Group	Fundamentals about Fractions Learning Achievement Test, Problem Solving Achievement Test 1 and Problem Solving Achievement Test 2	Worked example method	Fundamentals about Fractions Learning Achievement Test, Problem Solving Achievement Test 1 and Problem Solving Achievement Test 2
Control Group		Traditional teaching method	

While in the experimental group was applied the worked examples method, in the control group was applied the traditional teaching method.

Participants

The experimental group has 36 students in total (18 female, 18 male). The control group has 37 students (19 female, 18 male). Their ages range from 9 to 10 years. Students studying in the 4th grade of primary school were chosen as the participants of the study. The reason is that, according to the Primary School Mathematics Curriculum, the problem-solving outcomes related to fractions examined within the scope of the research occur for the first time at the 4th grade level. Due to students' pre-test scores not being normally distributed, the non-parametric test was applied. Mann Whitney U-Test results regarding the scores the students got on the pre-tests are given in Table 2.

Table 2. Pre-test success scores of the students in the study group Mann Whitney U Test results

Score	Group	N	Mean Rank	Sum of Ranks	U	p
Fundamentals about Fractions Learning Achievement Test	Control G.	37	36.16	1338.00	635.00	.72
	Experimental G.	36	37.86	1363.00		
Problem Solving Achievement Test 1	Control G.	37	37.20	1376.50	658.50	.93
	Experimental G.	36	36.79	1324.50		
Problem Solving Achievement Test 2	Control G.	37	37.77	1397.50	637.50	.72
	Experimental G.	36	36.21	1303.50		

Primary school 4th-grade students' scores from the Fundamentals about Fractions Learning Achievement Test (U=635.00, p>.05), from the Problem Solving Achievement Test 1 (U=658.50, p>.05), and from the Problem Solving Achievement Test 2 (U=637.50, p>.05) do not show any statistically significant difference with respect to being in the control or experimental group.

Measurement Tools

The research uses three two-tier achievement tests of varying difficulty levels developed by the researcher: the Fundamentals about Fractions Learning Achievement Test (FFL-AT), Problem-Solving Achievement Test 1 (PS-AT 1), and Problem-Solving Achievement Test 2 (PS-AT 1) (Ayvaz Can, 2018). The two-tier tests were developed by Treagust (1988). While the first tier of two-tier tests involves a multiple-choice question, the second tier involves a question about the reason for the answer to the first tier question (Haslam & Treagust, 1987). The necessity of revealing the reason in two-tier tests is a sensitive and effective way to measure students' meaningful learning (Tamir, 1989). The structure of the two-tier achievement tests is suitable for students who are able to express their own thoughts and reasoning easily during the problem-solving process, which is one of the objectives of the mathematics curriculum. An open-ended two-tier test type was used in the research from three different two-tier test types: multiple-choice, classification, and open-ended. Two-tier achievement tests were developed following the methods suggested by Treagust (1988) and Treagust and Chandrasegaran (2007) and consist of three parts. The first part takes the determination of the content into consideration. The second part takes the determination of conceptual knowledge into consideration. The third part lastly takes the tiers related to test development into consideration.

These tools scores ranged from 0 to 100. The reliability of FFL-AT was calculated as .92. Mean item difficulty was .716 and mean discrimination index was .536. The reliability of PS-AT 1 was calculated as .93. Mean item difficulty was .528 and mean discrimination index was .516. The reliability of PS-AT 2 was calculated as .92. Mean item difficulty was .282 and mean discrimination index was .468. The FFL-AT, PS-AT 1 and PS-AT 2 was implemented as a pre-test and post-test. According to the classification of different item difficulty index ranges, the item difficulty index range of easy questions in the study is .65-.79. Those with medium difficulty ranged from .35 to .64 and those of difficult questions between .20 and .34 (Crocker & Algina, 1986). PS-AT 1 consists of mid-difficulty fraction problems and AT 2 consists of high- difficulty fraction problems.

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ISSN: 1300 – 915X
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International Online Journal of Primary Education

2021, volume 10, issue 2

Procedure

Sakarya ranks 54th among Turkey's 81 provinces in terms of educational development level (Hendek District Strategic Plan, 2015). Sakarya's educational achievement is not at an acceptable level. The same is true for Sakarya's Hendek district. For this reason, conducting research to develop the math problem-solving skills of primary school students studying in Hendek has been deemed valuable. First, the teaching of 23 classroom teachers was observed one year before the experimental study in order to determine how the classroom teachers process the fraction sub-learning area to be examined in the study. At the end of the observations, it was observed that all classroom teachers presented the problems to the students by using means-ends analysis (saying/asking /writing what is given and what is asked). It was observed that no teacher used the worked examples method. A school was chosen randomly from the schools observed, and voluntarily participated in the study. There are 6 different 4th grade branches in this school. A pre-test was applied to all the students who wanted to participate in the study voluntarily in all branches. First, a branch was chosen as the control group. Afterwards, students from the other five branches who got close to the pre-test scores of the students in the control group were selected and the experimental group was formed. Accordingly, the research continued for a total of five weeks (20 lesson hours) at two days per week (4 lesson hours) at a primary school in Hendek. The time devoted to the learning outcomes to be addressed in the 5-week process was shared with the experimental and control groups before the experiment.

The training program applied in the experimental group was developed in accordance with the teaching principles of the worked examples method. This process investigated problem types related to fractions and created the categories of "fraction problem categories" by taking expert opinions. These categories are: "*fraction problems related to determining the specified fraction of a multiple*", "*fraction problems that require adding fractions with common denominators*", "*fraction problems related to subtracting fractions with common denominators*", "*fraction problems that require both addition and subtraction with common denominators*". The worked examples and problems presented to the students in each category in the experimental group and were included in the curriculum after obtaining expert opinion.

For instance, worked examples, completion examples and problem used in the category "Fraction problems related to finding the asked fraction of a multiplicity and proving the specified condition" are given below. This process has progressed as in Figure 1.

- There are 115 animals in a herd. $\frac{2}{5}$ of these are goats. How many goats are there in this herd? (Full worked example)
- An automobile covered first $\frac{2}{7}$ and then 65 km of the 280 km road. How many kilometres has the car covered? (Completion worked example 1)
- Mert will share $\frac{3}{4}$ of his 360 balls equally to his four friends. How many marbles will each get? (Completion worked example 2)
- A hardware store sells $\frac{1}{5}$ of a 40 m hose to a customer and $\frac{2}{5}$ to another customer. How many meters of hose did the hardware store sell to these two customers? (Problem)

Problems are presented in an order from easy to difficult. The problems are listed in a way where each forms the lower step of the subsequent problem. This way enables students to transfer their knowledge and skills from the previous problem to the solution for the next problem. In the experimental group, the teacher presented the worked examples to the students because the students are expected to model problem-solving processes from an expert. Students are not passive in this process. The teacher solved the problem by explaining the solution to the problem being solved. The teacher includes students in the problem-solving process by asking questions. The teacher provides enough (at least four for each category) worked examples and also asked problems for the students to solve independently. These problems the teacher asks consist of problems that can be solved in line with the experience obtained from the worked examples. This process is not planned as a contest. A completely learning-oriented climate was created.

The worked-example problems were solved in line with the problem-solving steps of Polya (1945). Polya's (1945) problem-solving steps were developed for math problems as a process consisting of four steps: understanding the problem, making a plan, implementing, and evaluating the plan. The problems were solved by using the figure drawing strategy, which is among Polya's (1945) problem-solving techniques (heuristics). Because primary school students are in the concrete operational period, the strategy of figure drawing is among the most appropriate strategies used in concretizing the problems. The problems solved within the scope of the research consist only of routine problems. While presenting the solutions of the worked-example problems to the students, the information is given in consecutive rows, not holistically.

The training program applied in the control group was performed in line with the Mathematics Lesson Teacher Guide, Mathematics Lesson Student Book, and Workbook approved by the Ministry of National Education. The lessons in the control group started with the problems presented in accordance with the traditional approach. In addition, the lessons continued with the subsequent problems the students were. In the experimental group, the learning process started with more than one worked example and continued with practice problems.

As a result, the different methods were used in the experimental and control groups within the scope of this research. The traditional problem-solving approach applied in the control group did not focus on developing an appropriate schema specific to the field. In the worked examples method applied in the experimental group, the focus was on developing schema or transforming the existing schema. In the experimental group in which the worked examples method is applied, the learning process was planned in a way where the learner would be able to transfer knowledge in the process of schema construction, development, and change. This was not the case in the group where the traditional problem-solving approach is applied.

Data Analysis

As a result of examining the kurtosis and skewness coefficients and Shapiro-Wilk test, the measurements of the dependent variables were found to not be normally distributed. The decision was made to use nonparametric statistics. The Wilcoxon signed-rank test was used to compare the pre-test and post-test success scores for the students in both the experimental and control groups (Table 3 and Table 4). The Mann-Whitney U test is used for comparing the experimental and control groups' post-test success scores (Table 5). A p value of$<.05$ was taken as statistically significant. Effect size is a standard measure showing how much effect the independent variable has on the dependent variable (Murphy & Myors, 2004). For this reason, the effect size was also examined in the research. Effect sizes ranges have low level if $r<.20$, medium level if $.20<r<.50$, and high level if $r>.50$ (Cohen, 1988). Two experts worked separately for the scoring of the open-ended second stage of the two-stage achievement tests. The reliability of the research was ensured by considering the consistency among the evaluators.

RESULTS

The research first tested Sub-Hypothesis 1 (The worked examples method has an effect on the development of primary school 4th-grade students' achievement of learning the fundamental knowledge about fractions and solving mid- and high-difficulty fraction problems). The obtained findings are given in Table 3.

When examining Table 3, a statistically significant difference is seen to exist between the success scores for learning fundamental knowledge (z=-5.28, p<.05) about fractions before and after the experiment of the students learning about fractions with the worked examples method solving mid-difficulty fraction problems (z=-5.32, p<.05) and high-difficulty fraction problems (z=-5.29, p<.05). Considering the mean rank and totals of the different scores, these observed differences are seen to favor the post-test score. Accordingly, the worked examples method has an effect on students' learning the fundamental knowledge about fractions and developing their success in solving mid- and high-difficulty fraction problems.

Table 3. Comparing the pretest and posttest success scores of the experimental group learning fractions with the worked examples method

Score	Group	N	Mean Rank	Sum of Ranks	z	p	r
	Negative Ranks	0	.00	.00	-5.28	.00	-.88
FFL-AT	Positive Ranks	36	18.50	666.00			
	Ties	0					
	Negative Ranks	0	.00	.00	-5.32	.00	-.89
PS-AT 1	Positive Ranks	36	18.50	666.00			
	Ties	0					
	Negative Ranks	0	.00	.00	-5.29	.00	-.88
PS-AT 2	Positive Ranks	36	18.50	666.00			
	Ties	0					

The effect of the worked examples method on increasing the success of learning fundamental knowledge about fractions is -.88. Its effect on increasing success in solving mid-difficulty fraction problems is -.89. Its effect on increasing success in solving high-difficulty fraction problems is found to be -.88. These findings show the worked examples method to have a high-level effect on increasing students' success in fractions. As a result, Sub-Hypothesis 1 is accepted.

The research also tested Sub-Hypothesis 2 (Traditional teaching methods have an effect on primary school 4th-grade students' learning fundamental knowledge about fractions and on developing their success in solving mid- and high-difficulty fraction problems). The obtained findings are given in Table 4.

Table 4. Comparing the control group's pretest and posttest success scores on learning about fractions using traditional teaching methods

Score	Group	N	Mean Rank	Sum of Ranks	z	p	r
	Negative Ranks	0	.00	.00	-3.28	.00	-.54
FFL-AT	Positive Ranks	36	18.50	666.00			
	Ties	1					
	Negative Ranks	0	.00	.00	-2.22	.00	-.37
PS-AT 1	Positive Ranks	34	17.50	595.00			
	Ties	3					
	Negative Ranks	2	4.5	9.00	-1.07	.13	
PS-AT 2	Positive Ranks	22	13.23	291.00			
	Ties	13					

When examining Table 4, a statistically significant difference is seen between pre- and posttest success scores for learning fundamental knowledge (z=-3.28, p<.05) about fractions for the students learning about fractions with the traditional teaching method for solving mid-difficulty fraction problems (z=-2.22, p<.05). However, no statistically significant difference was concluded to have occurred between the pretest and posttest success scores (z=-1.07, p>.05) for solving high-difficulty fraction problems. When considering the differences in mean rank and totals of the scores, the observed differences is seen to be in favor of the post-test score. Accordingly, the traditional teaching method has an effect on developing students' success in learning fundamental knowledge about fractions and solving mid-difficulty fraction problems but no effect on developing success in solving high-difficulty fraction problems.

The effect of traditional teaching methods on increasing the success in learning fundamental knowledge about fractions is -.54. Its effect on increasing success in solving mid-difficulty fraction problems is found to be -.37. The traditional teaching method has a moderate effect on increasing students' success in learning fundamental knowledge about fractions while solving mid-difficulty fraction problems. However, this method does not have an effect on increasing students' success in solving high-difficulty fraction problems. As a result, Sub-Hypothesis 2 has been partially accepted. Increases in the achievement scores for the students in the experimental and control groups for the pretest and posttest scores are given in Figure 4.

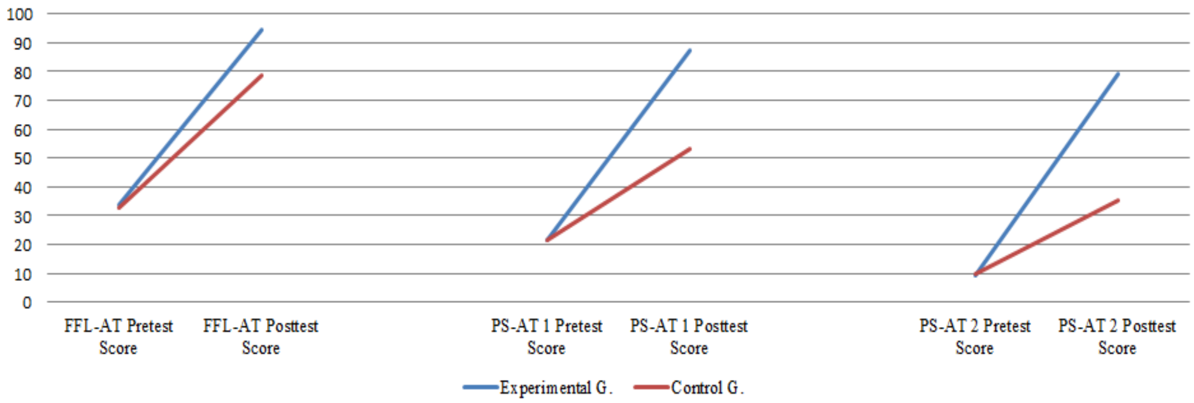

Figure 4. Comparison of the success scores from students in the experimental and control groups for the pre-test and post-test

For students in the control group, the average FFL-AT score increased from 32.97 to 78.65, the average PS-AT 1 score increased from 21.62 to 52.97 and the average PS-AT 2 score increased from 9.73 to 35.14. Their average FFL-AT score increased by 45.68 points, their average PS-AT 1 score increased by 31.35 points, and their average PS-AT 2 score increased by 25.41 points.

For the students in the experimental group, the average FFL-AT score increased from 33.61 to 94.44, the average PS-AT 1 score increased from 21.68 to 87.22, and the average PS-AT 2 score increased from 9.45 to 79.45. Their average FFL-AT score increased by 60.83 points, their average PS-AT 1 score increased by 65.54 points, and their average PS-AT 2 score increased by 70 points.

When examining Figure 4, the average post-test success scores for students in both the experimental and control groups were higher than their pretest average success score for all three tests. In this way, the research tests Sub-Hypothesis 3 (The effects of the worked examples method and the traditional teaching method differ from each other in how primary school 4th-grade students learn fundamental knowledge about fractions and how they develop success in solving mid- and high-difficulty fraction problems). The obtained findings are given in Table 5.

Table 5. Comparing the post-test success scores for students in the experimental and control groups

Score	Group	N	Mean Rank	Sum of Ranks	U	p
FFL-AT	Control G.	37	22.15	819.5	116.50	.00
	Experimental G.	36	52.26	1881.5		
PS-AT 1	Control G.	37	20.46	757.00	54.00	.00
	Experimental G.	36	54.00	1944.00		
PS-AT 2	Control G.	37	23.19	858.00	155.00	.00
	Experimental G.	36	51.19	1843.00		

The scores obtained from the FFL-AT, which measures the success of 4th-grade students in the experimental and control groups on learning fundamental knowledge about fractions, show a statistically significant difference with respect to their groups (U=116.50, $p<.05$). When considering the mean rank (MR), the success scores of students in the experimental group (MR_{exp}=52.26) were found higher than those in the control group (MR_{cont}=22.15). Based on this finding, the worked examples method has been concluded to be more effective than the traditional teaching method in increasing student success in learning fundamental knowledge about fractions.

The scores for the 4th-grade students in the experimental and control groups from the PS-AT 1, which includes the mid-difficulty fraction problems, show a statistically significant difference when comparing the experimental and control groups (U=54.00, $p<.05$). When considering the *MR*, the success scores for the students in the experimental group (MR_{exp}=54.00) are found to be higher than those in the control group (MR_{cont}=20.46). Based on this finding, the worked examples method is concluded to be more effective than the traditional teaching method in increasing student success in solving mid-difficulty fraction problems.

The scores for the 4th-grade students in the experimental and control groups from the PS-AT 2, which includes high-difficulty fraction problems, show a statistically significant difference according to the groups they are in (U=155.00, $p<.05$). When considering the *MR*, the success scores for the students in the experimental group (MR_{exp}=51.19) are found to be higher than those in the control group (MR_{cont}=23.19). Based on this finding, the worked examples method is concluded to be more effective than the traditional teaching method in increasing student success in solving high-difficulty fraction problems.

DISCUSSION and CONCLUSION

This research has aimed to reveal whether the teaching method primary school teacher's use in mathematics lessons has an effect on primary school students' mathematics achievement. In this context, the effects of the worked examples method and the traditional teaching method have been compared. At the end of the experimental procedures, the worked examples method was found to be more effective than the traditional teaching method. The reason for this is thought to be that the worked examples method reduces the extraneous cognitive load of primary school students with little experience; extra cognitive loads negatively affect learning in the process of complex skill acquisition. In addition, not exceeding the capacity of the working memory is considered as another reason why the worked examples method is effective.

The research has also found the worked examples method to be more effective than the traditional teaching method in developing the achievement of primary school 4th-grade students in learning fundamental knowledge. When reviewing the literature, the worked examples method is seen to be an effective method in teaching fundamental knowledge and concept knowledge. Kim, Weitz, Heffernan, and Krach (2009) concluded the worked examples method to be an effective method for students to acquire conceptual knowledge. Özcan, Kılıç, and Obalar (2018) stated that students' success in showing fractions on the number line increased in their research using the worked examples method. At the end of an experimental study on the worked examples method, Tüker (2013) found it to be an effective method for students to understand a subject. As a result of the research conducted by Booth et al. (2013), the worked examples method was found to be useful in developing conceptual understanding in students. With the use of the worked examples method, students learn fundamental information and concepts more easily as they have better learning performance (Carroll, 1994; Zhu & Simon, 1987). Zhu and Simon (1987) found that students in classrooms applying the worked examples method showed better learning performance than students in classrooms using traditional methods. Carroll (1994) found students in algebra classes to benefit more from the application processes of the worked examples method compared to traditional applications. The results obtained by Kim, Weitz, Heffernan, and Krach (2009); Tüker (2013); Özcan, Kılıç, and Obalar (2013); Zhu and Simon (1987); and Carroll (1994) support this study's conclusion that the worked examples method is an effective method for students to learn fundamental knowledge obtained from this study.

The research found the worked examples method to be more effective than the traditional teaching method in improving the success of primary school 4th-grade students in solving mid- and high-difficulty problems. The most important prerequisite for successfully solving problems is to know the schemata appropriate to the problem type (Gick & Holyoak, 1983; Reed, 1993). When a problem is encountered, if this problem belongs to a problem category with known structural properties, the relevant schema is taken from memory. The worked examples method has proven to be one that supports schema acquisition according to problem types, especially in the early stages of skill acquisition (Gerjets, Scheiter, & Catrambone, 2006). The situations emphasized in the literature by Gick and Holyoak (1983) and Gerjets, Scheiter, and Catrambone (2006) support this study's result that the worked examples method is an effective method for improving problem-solving skills.

This research showed the problem-solving performance of the students in the experimental group, which used the worked examples method to be higher than that of the students in the control group. In other words, the results from the research observed the positive effects worked examples have on problem-solving performance. A worked example consists of a problem statement, the steps leading to a solution, and a final answer; worked examples guide students about a systematic and complete problem-solving process (Atkinson, Renkl, & Merrill, 2003; Renkl, 1997). This guidance helps students develop problem-solving skills and perform better in problem-solving processes (Rourke & Sweller, 2009; Van Gog, Kester, & Paas, 2011). This situation supports the fact that the problem-solving success of students in the control group who were not applied this guidance within the scope of the purpose of the research was lower than the success of the students in the experimental group. In the literature, Hurioğlu and Efendioğlu (2017) concluded the worked examples method to be effective in providing students with problem-solving skills, which also supports the result of this research. Kusuma and Retnowati (2021) conducted a research to improve problem-solving skills and operational fluency. The results from their study stated the worked example method to be effective in gradually gained problem-solving skills and operational fluency. In addition, Kusuma and Retnowati (2021) stated that worked examples provide informational aid to novice students that can be used as scaffolding. The results obtained from this study are consistent with the results they obtained. In addition, Corral, Quilici, and Rutchick (2020) examined the effect of schema acquisition on math problem solving in their research. Students were shown to have benefited from worked examples in the schema-acquisition process. The results from their study found the participants in the group in which worked examples had been applied to show better problem-solving performance.

The current research has found the worked example method to be effective at increasing students' success in solving difficult problems. However, the traditional teaching method was not found to be an effective method. When examining the literature, Chen, Retnowati, and Kalyuga (2020) are seen to have conducted experimental research on worked examples. Participants from their study were 52 primary school students. At the end of the research, they concluded choosing the worked examples method to be advantageous in teaching complex problem-solving steps to primary school students, who they defined as novice students. Stating the process of solving difficult problems to involve complex cognitive processes, Berthold, Eysink, and Renkl (2009); Jones (2014); Rourke and Sweller (2009); Van Gog, Paas, and Van Merriënboer (2006); and Van Gog, Kester, and Paas (2011) found the worked examples method to be effective on complex learning processes. The results obtained from the studies in the literature coincide with the results from this research.

Difficult problems are not problems that can be solved by memorization. Students in the class in which the worked examples method had been applied did not solve difficult problems by memorization. Worked examples are used as teaching tools that reflect the problem-solving processes of an expert and enable students to learn by imitating the experts' processes. Students model creative problem-solving processes this way (Mayer, Sims, & Tajika, 1995). Thus, one example of the problem-solving approach is presented rather than suggesting a list of steps offered to the student to memorize (Pease, 2012). The increase in the performance of students in the experimental group while solving difficult problems shows that the students do not solve these problems by rote. It also shows that they used the example of the problem-solving approach presented in the worked examples.

This research uses the two-tier success test. The first tier of the tests consists of marking the correct option. The second tier of the tests consists of explaining the operations done for solving the problem. The student who complete both tiers correctly got full points. At the end of the experiment, a difference was found in favor of the experimental group in terms of the the problem-solving successes of the two groups. This situation shows the students in the group in which the worked examples method had been used to have been able to explain the reasoning steps correctly while solving the problems. According to Budé, Van De Wiel, Imbos, and Berger (2012), students with little experience in problem solving often fail to explain the reasoning steps internally while solving a problem.

Therefore, the use of worked examples benefits this process. This benefit from using worked examples is also reflected in the research results.

In this research, students' success in solving fraction problems was developed using the worked examples method over a short time of 5 weeks. The performance of students who learned through the worked examples method in this short time was found to be higher than for the students who learned using the traditional teaching method. The results obtained from Paas and Van Merriënboer (1994) showed the worked examples method to be effective over a short time. In addition, studies have shown trying to solve problems to take more time than studying examples (Sweller, 2006). This situation shows the performance of students who learn using the worked examples method to improve over a short time.

Although many studies have determined the worked examples method to be effective (Carroll, 1994; Cooper & Sweller, 1987; Crissman, 2006; Pawley, 2004; Lee, Nicoll, & Brooks, 2004; Shen, 2005; Sweller & Cooper, 1985; Zhu & Simon, 1987), researchers' opinions are divided on certain issues. Some researchers have claimed the worked examples method to not be universally effective for students (Catrambone & Holyoak, 1989; Renkl, 1999; Ward & Sweller, 1990). According to these researchers, students have claimed being unable to apply what they learned with the worked examples method to new problems due to differences in the presentation of worked examples or individual differences such as students' prior knowledge levels. Some studies have shown that, while teaching through worked examples is effective for students with little problem-solving experience, it can reduce the performance of more experienced students (Bokosmaty, Sweller, & Kalyuga, 2015). Faulkner (1999) used a problem-based teaching method in one group and the worked examples method in the other group. At the end of the research, Faulkner found no statistically significant difference to be present in the success scores of the two groups. This result Faulkner found does not coincide with the results from the current research. The reason for the different results and opinions is considered to be the country, year, grade level, and individual differences of the students in the research group. Variables such as being experienced or not are also thought to affect the different results and opinions.

This research has shown the worked example method to be more effective than the traditional teaching method for learning fundamental knowledge and improving success in solving mid- and high-difficulty fraction problems for primary school students who still lack sufficient experience.

Limitations and Suggestions

In terms of the study group, the research is limited to students attending the fourth grade of a primary school and participating in the application. In terms of subject, this research is limited to the sub-learning area of fractions in the numbers learning area in the Primary School Mathematics Curriculum. The effects of worked example method on other grade levels and other mathematical subjects can be investigated. In addition, the effects of the worked example method can be studied at the primary school level in the field of science.

In the research, it was found that the worked examples method is an effective method in improving the performance of solving medium and difficult problems. For this reason, problem type classification can be made for all levels and subjects of primary school and in accordance with worked examples method. Student textbooks and workbooks can be created by taking these classifications into consideration. In this way, students' problem solving performance can be improved by supporting the schema development.

Ethics Statement and Funding Information

For this research, necessary permission was obtained from the R&D Commission of the Provincial Directorate of National Education. In addition, the permission of the Ethics Committee was obtained by the resolution of the Social and Human Sciences Ethics Committee at Erciyes University dated 27.07.2021 No. 347. The rules of scientific, ethical and citation were followed in the writing process of the study titled "The Effect of Worked Examples Method on Primary School Students' Fractions

Achievement". This research conducted by author's doctoral thesis was supported by TUBITAK (The Scientific and Technical Research Council of Turkey) 2211-A Doctoral Scholarship.

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