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The Effect of Self-Explanation Prompts and Fading Steps in Worked-out Examples on Students' Fraction Problems Performance

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Abstract

Recent studies have shown that worked-out examples are considered as an alternative approach for students who don't have prior knowledge of a task or initial acquisition in domains like mathematics. Worked-out examples involve the presentation of a problem and its solution. The primary purpose of this study was to investigate the relative effects of four different types of worked-out examples (worked-out examples, worked-out examples with self-explanation prompts, fading worked-out examples without self-explanation prompts and fading worked-out examples with self-explanation prompts) on novice students' math performance on fraction problems. The study group consisted of 67 students that were selected among 215 sixth grade students from a public school. According to the results of this study, the use of self-explanation prompts in combination with backward fading worked-out examples fosters learning in both transfer and follow-up studies. Backward fading worked-out

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examples using self-explanation prompts can be easily implemented and is compatible with ordinary framework conditions in schools with very simple means such as worksheets or homework.

Keywords: Worked-out examples; Self-explanation prompts; Fading steps; Mathematics; Cognitive load.

Açıklayıcı İpuculu ve Silikleştirilerek Basamaklandırılmış Çözümlü Örneklerin Öğrencilerin Kesir Problemleri Performansına Etkisi

Öz

Son yıllarda yapılan araştırmalar çözümlü örneklerin herhangi bir konuda veya matematik gibi alanlarda ön bilgileri yeterli olmayan öğrenciler için alternatif bir yaklaşım olduğunu göstermektedir. Çözümlü örnekler soruyu ve çözümünü içerir. Bu araştırmanın amacı dört farklı çözümlü örnek türünün (çözümlü örnekler, açıklayıcı ipuculu çözümlü örnekler, silikleştirilerek basamaklandırılmış çözümlü örnekler ve silikleştirilerek basamaklandırılmış ve açıklayıcı ipuculu çözümlü örnekler) başarısı düşük olan öğrencilerin kesir problemleri performansına etkisini incelemektir. Çalışma grubu bir devlet okulunda okuyan 215 altıncı sınıf öğrencisi arasından seçilmiş 67 öğrenciden oluşmaktadır. Bu araştırmanın sonuçlarına göre silikleştirilerek basamaklandırılmış ve açıklayıcı ipuculu çözümlü örneklerin hem transfer hem de izleme testinde diğer çözümlü örnek türlerine göre başarıyı daha fazla geliştirdiği sonucuna ulaşılmıştır. Silikleştirilerek basamaklandırılmış ve açıklayıcı ipuculu çözümlü örnekler sıradan okul ortamlarında ödevler veya sınıf çalışmaları yoluyla kolaylıkla uygulanabilir.

Anahtar Kelimeler: Çözümlü örnekler; Açıklayıcı ipuçları; Silikleştirilerek basamaklandırma; Matematik; Bilişsel yük.

Introduction

Although fractions have been known since ancient times, they still pose major problems when learning mathematics. The processing of fractions play a key role in not only mathematics but also everyday life (Gabriel, Coché, Szucs, Carette and Rey, 2013). Fractions were defined as students’ first serious confrontation with abstraction and understanding fractions is the most critical step in understanding rational numbers (Wu, 2009). Understanding fractions, within the context of word problems and algebraic understanding often affects student success in mathematics critically (Olson and Olson, 2013). Understanding difficulties in learning fractions seems absolutely crucial as they can lead to mathematics anxiety, and affect opportunities for further engagement in mathematics and science (Gabriel, Coché, Szucs, Carette and Rey, 2013). Despite the fact that many studies have been done to determine students' mistakes/misconceptions about fractions problems, it seems that there needs to be more studies to eliminate those issues.

Although self-directed problem solving is very popular in new curriculums (e.g. National Council of Teachers of Mathematics [NCTM], 2000; Turkish Ministry of National Education [MNE], 2013), recent research studies have shown that worked-out examples are considered as an alternative approach for students who don't have prior knowledge of a task (Bokosmaty, Sweller and Kalyuga, 2015; Van Loon-Hillen, Van Gog and Brand-Gruwel, 2012) or initial acquisition in domains like mathematics (Renkl, 1999), and they have received considerable attention for the last twenty years (e.g. Bokosmaty, Sweller and Kalyuga, 2015; Renkl, Atkinson, Maier and Staley, 2002). In literature, it is emphasized that worked-out questions have the potential to eliminate students' difficulties in learning important subjects of mathematics like fraction problems. Worked-out examples involve the presentation of a problem and its solution (Atkinson, Renkl and Merrill, 2003; Renkl, Atkinson, Maier and Staley, 2002). The solution is usually presented step by step (Atkinson, Derry, Renkl and Wortham, 2000) and accompanied with additional explanations that help the learner comprehend the structure of the problem (Schunk, 2011).

The importance of worked-out examples can be explained by their association with cognitive load theory (CLT) (e.g. Bokosmaty, Sweller and Kalyuga, 2015; Reisslein, Reislein and Seeling, 2006; Renkl and Atkinson, 2003; Van Loon-Hillen, Van Gog and Brand-Gruwel, 2012) developed by John Sweller (1988) in the late 1980s. CLT is defined as "the amount of effort needed by the human cognitive system to process information" by Sweller (1988). Moreover, it refers to the total amount of mental effort used in the working memory. As Miller (1956) indicated, working memory is limited in capacity. While acquiring new information about complex knowledge domains like mathematics, working memory can be overloaded (Kalyuga, 2009). CLT assumes that the available knowledge structures in long term memory (i.e. prior knowledge) are essential for preventing working memory overload (Van Merriënboer and Sweller 2005). Most people can store 7±2 bits of information in their working memory (Miller, 1956). The amount of bits of information depend on students' prior knowledge or available knowledge structures in long-term memory. The size of bits is likely to increase as students' prior knowledge increases. As a result, cognitive load is high when a subject matter makes high demands on working memory (Leppink, Broers, Imbos, Van der Vleuten and Berger, 2012).

Cognitive load has three components; intrinsic load, extraneous load, and germane load (Sweller, Van Merriënboer and Paas, 1998). Intrinsic load depends on both the complexity of a task and students' prior knowledge about it. This type of load is independent from teaching method and can be reduced by selecting learning tasks that match students' prior knowledge (Kalyuga, 2009; Sweller, Van Merriënboer and Paas, 1998). Extraneous load is caused by instructional method that does not contribute to learning (Sweller, Van Merriënboer and Paas, 1998). Germane load is associated with processes that are directly relevant to learning such as scheme construction (Van Merriënboer and Ayres, 2005). Germane load is then assumed to represent the working memory resources that are required to deal with intrinsic load, caused by the complexity of the learning materials (Paas, Van Gog and Sweller, 2010). When cognitive load is caused by activities or information that do not directly have an impact on learning, this is called extraneous load; on the other hand, germane load contributes to learning by information process (Kirschner, Kester and Corbalan, 2011). Thus, it is especially important to explore ways of fostering germane load from an instructional perspective. An effective teaching technique to accomplish this is to use worked-out examples in instructions (e.g. Atkinson, Derry, Renkl and Wortham, 2000; Bokosmaty, Sweller and Kalyuga, 2015; Kalyuga, Ayres, Chandler and Sweller, 2003).

Worked-out examples are believed to facilitate schema construction of learners (Chandle and Sweller, 1991). If the learner becomes familiar with the material, the cognitive characteristics associated with the material change and the learner starts to use working memory more efficiently. This is known as "worked-out example effect" (Sweller, 1988). Especially for novices who have insufficient or partly incorrect prior knowledge, worked-out examples are generally more effective for learning and transfer, and higher learning is obtained with less investment of time or mental report (Atkinson, Derry, Renkl and Wortham, 2000; Van Gog and Rummel, 2010). Novice students learn more from studying worked-out examples (i.e., problems with a worked-out solution) than from solving problems or imagining the solution steps themselves (e.g. Kalyuga, Ayres, Chandler and Sweller, 2003).

A large number of studies have demonstrated the benefits of worked-out examples especially in domains such as mathematical problem solving (e.g. Renkl, Atkinson, Maier and Staley, 2002), mathematics (e.g. Renkl, Stark, Gruber and Mandl, 1998), geometry (e.g. Bokosmaty, Sweller and Kalyuga, 2015), statistics (e.g. Bude, Van de Wiel, Imbos and Berger, 2012), chemistry (e.g. Gerjets, Scheiter and Catrambone, 2006; Ngu and Yeung, 2013) and physics (e.g. Van Gog, Paas and Van Merriënboer, 2006). In these studies, worked-out examples were implemented in computer based environments (e.g. Hilbert, Renkl, Schworm, Kessler and Reiss, 2008; Atkinson, Renkl and Merrill, 2003) or through written or oral instructions (e.g. Van Loon-Hillen, Van Gog and Brand-Gruwel, 2012). Worked-out examples not only increase the performance of students but also reduce the time to complete the subject. Zhu and Simon (1987) indicated in their study that it took three years for students who were given traditional instruction to complete a math course in algebra and geometry, while students who were presented worked-out examples during instruction completed the same math course within two years in a Chinese middle school, with higher average scores on standardized math tests at the end of the experiment.

Although research studies indicate the advantages of worked-out examples, not all worked-out examples are beneficial for all students all the time (Bokosmaty, Sweller and Kalyuga, 2015; Renkl, Atkinson, Maier and Staley, 2002). For example, no significant learning effect was found in some studies (Darabi, Nelson and Palanki, 2007; Tarmizi and Sweller, 1988) especially on far mathematical problem solving transfer (Moreno, 2006). As mentioned above, a worked-out example presents learners a problem with solution steps, but what the learner needs is to mentally integrate those sources of information. Therefore, there is a need for special types of worked-out examples.

Several strategies have been proposed to overcome the claimed limitations of standard worked-out examples. Gradual fading of worked-out steps (Renkl and Atkinson, 2003; Renkl, Atkinson, Maier and Staley, 2002) is one of these strategies. With this type of worked-out examples, a complete worked-out example is presented to the learner at first. Next, the last step in the solution is not given and expected to be solved by the learner. Then, the last two solution steps are not done and expected to be done by the learner.

This process of reducing the worked solution steps continues until all the worked solution steps are faded away. Finally, the learner has to solve the entire problem independently. This kind of fading is called backward fading. In contrast, in a forward fading design, the worked solution steps are faded beginning with the first solution step. Studies show that backward fading generally results in higher learning performance at the domain of mathematics (Atkinson, Renkl and Merrill, 2003; Fleischmann and Jones, 2002; Renkl, Atkinson, Maier and Staley, 2002).

Another strategy to overcome the limitations of standard worked-out examples is the use of self-explanation prompts (Renkl and Atkinson, 2003). Self-explanation means that the learner is explaining a learning material to herself/himself in order to understand it (Chi, Bassok, Lewis, Reimann and Glaser, 1989). Studies show that students who are encouraged to use self-explanation strategy while learning perform better at problem-solving tasks (Chi, DeLeeuw, Chiu and LaVancher, 1994). Since some students, especially novices are not self-explainers (Renkl, 1997, 1999), it has been suggested to use self-explanation prompts that are intended to reveal the activity of self-explanation as external cues. (Berthold, Eysink and Renkl, 2009). Prompts are generally embedded in the learning material and self explanation prompts are used in studies related to worked-out examples (Berthold, Eysink and Renkl, 2009).

Although there are few studies comparing self-explanation prompts with fading, these studies either are conducted with university students (Renkl, Atkinson, Maier and Staley, 2002; Atkinson, Renkl and Merrill, 2003) or use a computer based learning environment (Atkinson, Renkl and Merrill, 2003) which is almost impossible in Turkey's conditions because of the limited number of computers, slow Internet connections, insufficient software in the native language, and a lack of peripheral equipment at schools (Akbaba-Altun, 2006). In addition, although there are a lot of studies that emphasize the worked-out examples' important effects on novice students (Van Loon-Hillen, Van Gog and Brand-Gruwel, 2012; Renkl, 2002), few studies use novice samples (Van Gog, Kester and Paas, 2011). It can be concluded that there is a need for research studies related to the effectiveness of worked-out examples on novice students. Moreover, most studies either use volunteer students (e.g. Renkl, Stark, Gruber and Mandl, 1998) or choose a sample with quasi-experimental methods (e.g. Van Loon-Hillen, Van Gog and Brand-Gruwel, 2012) instead of using novice students as sample. Thus, primary purpose of this study was to investigate the relative effects of four different types of worked-out examples (worked-out example, worked-out examples with self-prompts, fading worked-out examples without self-prompts and fading worked-out examples with self-prompts) on novice students' math performance on fraction problems, which is one of the most important topics in middle school education.

The research questions of this study were;

1. What are the relative effects of four different types of worked-out examples on students' fraction problems performance on learning process, transfer and follow-up scores?
2. Does using self-prompts produce more favorable learning outcomes than not using self-prompts on students learning process, transfer and follow-up scores?
3. Does using backward fading produce more favorable learning outcomes than not using backward fading on students learning process, transfer and follow-up scores?

Method

Participants and Design

The participants were selected among 215 sixth grade students from a public school in Turkey. Novice students were selected via a pretest of fractions. 67 students who couldn't solve fraction problems (those students get the score under 40 out of 100) but were successful in doing the four operations (those students get the score above 60 out of 100) related with fractions were selected as the study group and they were divided into 4 groups randomly. These four groups were assigned as experimental group 1 -worked-out example (n=19), experimental group 2 -worked-out examples with self- prompts (n=15), experimental group 3-fading worked-out examples without self-prompts (n=18) and experimental group 4-fading worked-out examples with self- prompts (n =15).

Instruments

Pretest

The pretest consisted of two parts. In the first part, 10 questions related to four operations of fractions were asked. The objectives of this part were being able to do addition, subtraction, multiplication and division with fractions, finding whole of a given fraction and finding part of a fraction. In the second part of pretest, 10 questions were asked related to fraction problems.

The objective of this part was being able to solve word problems related fraction operations. Partial credits were given for all questions of two parts. 0 point was given if the answer was totally wrong or there was no answer at all; 3 point was given to an incomplete and/or incorrect solution providing evidence in attempt to solve the problem; 6 point was given for incorrect solution by selecting appropriate strategies; selecting appropriate procedures/strategies to solve the problem, but the solution was not entirely correct; 10 was given for totally correct solution, so the maximum score to be achieved for each part was 100. Pretest results of students were scored independently by the researcher and two mathematics teachers independently. The scores were compared and 95 % agreement was reached.

Learning Performance While Examining Worked-out Examples

There were five parts representing five different types of fraction problems in the worked-out examples worksheet. After examining each part, one question is presented to the student to answer. Examples of these five types of fraction problems that were under each part are given below. Students' performance while examining the worked-out examples was measured by these five questions. Each question was worth 10 points; thus, the maximum score that could be achieved was 50. Learning performance scores of students were scored independently by the researcher and four mathematics teachers independently. The scores were compared and 99 % agreement was reached.

What is 3/11 of 4/5 of 5/3 of 55?

If 2/5 of $\frac{1}{3}$1/3 of 9/8 of a number is 66, what is this number?

A person walked 3/7 of a road that is 540 meters long. How many meters does she have left to walk?

I have 600 Turkish liras. I spent 1/5 of it for DVD and 2/3 of it for a book. How much money do I have left?

A person spends 2/3 of her money on a notebook and 1/4 of it on a pencil. She has 6 Turkish liras left. How much money did she have at the beginning?

Transfer Test

After the intervention, the transfer test consisting of two problems was conducted. These types of problems were not solved before. Each question was worth 10 points, so the maximum score that could be achieved was 20. Transfer test results of students were scored independently by the researcher and two mathematics teacher independently. The scores were compared and 95% agreement was reached. These questions were not similar to the questions that were included in the worked out examples. These two problems are given below:

> "An athlete firstly ran 3/5 of the track that he had to run, then he ran 5/6 of the remaining distance. If he had 30 meters left to run, what is the total length of the running track?
>
> A tailor used 4/7 of 21/16 of 660 meters fabric. Then, he used 1/5 of the remainder to sew a shirt. How many meters of fabric is left?"

Follow-up Test

One week later, the follow-up test consisting of four problems similar to the questions students worked on during the intervention was conducted. Each question was worth 10 points, so the maximum score that a student can get was 40. The follow-up test results of students were scored independently by the researcher and two mathematics teacher independently. The scores were compared and 95% agreement was reached.

The problems in the follow-up test are given below.

> What is 3/11 of 4/5 of 5/3 of 55?
>
> If 2/5 of 1/3 of 9/8 of a number is 33, what is this number?
>
> I walked 1/5 of a road that is 3000 meters long. How many meters do I have left to walk?
>
> An athlete first ran 3/5 of a track, and then, he ran 1/10 of the track. He has 45 meters left to run. What is the total length of the running track?

Procedure

The topic of this experiment was fraction problems that had been previously studied by the students. The pretest consisting of two parts (four operations related to fractions and fraction problems) was administered one week before the treatment. According to the results of the pretest, students who performed well in the first part but didn't perform well in the second part were selected as the study group. A week after the selection of the study group, the instruction was carried out by the researcher in a classroom, using a worksheet consisting of worked-out examples. Except for the transfer questions, the problems used in pretest and worked-out examples were selected from their books and approved by six teachers who were working at this public school. The transfer questions were prepared by the researcher with the help of these teachers. All of the teachers indicated that students did not encounter these types of questions in their classroom.

The worksheet to teach students fraction problems included worked-out examples consisting of five parts representing five different types of fraction problems and two transfer questions. Completion of this worksheet required 80 minutes; which is the duration of two lessons with 10 minutes break in between. Other than the type of worked-out examples, conditions and problems used were the same for all treatment groups. For each treatment group, a series of printed worked-out examples were used which are: (a) worked-out examples (b) worked-out examples with self-explanation prompts; (c) fading worked-out examples (d) fading worked-out examples with self-explanation prompts.

In the worked-out example group, the solutions of 2 or 3 questions (depending on numbers of steps) were given in stepwise manner for each part and one similar problem was expected to be solved by students in each part. A sample problem from worked-out examples and its solution are given below.

A Worked-out Example

2/5 of a field is planted with wheat and 3/15 of it is planted with bean. If the area left unplanted is 120 square meters, what is the total area of the field?

First step: 2/5+3/15=9/15=3/5 (The planted field as a fraction)

Second step: 5/5-3/5=2/5 (The rest of the field as a fraction)

Third step: 120:2=60   60×5=300 square meters (The total of the field)

Two more questions that were similar to this question and their answers were given to the students and one similar problem was expected to be solved by the students.

In the worked-out examples with self-explanation prompts group, the solutions of the problems with self-explanation prompts were given in stepwise manner in each part and again for each type of questions, one similar problem were expected to be solved by the students. A sample question and its solution are given below.

A Worked-out Example with Self-explanation Prompts

2/5 of a field is planted with wheat and 3/15 of it is planted with bean. If the area left unplanted is 120 square meters, what is the total area of the field?

First step:

Let's find the planted area as a fraction.

So we will add 2/5 and 3/15.

2/5+3/15=9/15=If we simplify it, it we will find 3/5. (We found the total area of the planted field as a fraction.)

Second step:

Let's find the area of the field that is not planted.

To find the area of the field that is not planted, we will subtract the planted part from the total. Remember the total is 1. In this question you can take it as 5/5.

5/5-3/5=2/5 (We found the rest of the field as a fraction.)

Third step:

2/5 of a number is 120, let's find this number.

To find the number whose fraction is given, divide it by the numerator and multiply it by the denominator.

120:2=60   60×5=300 square meters (We found the total area of the field.)

Two more questions that were similar to this one and their answers with self-explanation prompts were given to the students and students were expected to solve one similar problem.

In fading worked-out examples group, the researcher presented the solutions of the problems in the following order: (a) a complete example, (b) an example with the last solution step left out, (c) an example with the last two steps omitted, and (d) a problem in which all three steps were missing (backward fading). In contrast, in the worked-out example and worked-out example with self-prompt groups, complete examples and answers were presented twice and it was followed by a corresponding problem. In fading worked-out examples with self-prompts group, the solutions of the problems were given the same as fading worked-out examples group. However, this time self-prompts were given at each stage.

Fading Worked-out Examples

Example 1. 2/5 of a field is planted with wheat and 3/15 of it is planted with bean. If the area left unplanted is 120 square meters, what is the total area of the field?

First step: 2/5+3/15=9/15=3/5 (The planted field as a fraction)

Second step: 5/5-3/5=2/5 (The rest of the field as a fraction)

Third step: 120:2=60 60×5=300 square meters (The total of the field)

Example 2. An athlete first ran 3/5 of a track, then he ran 1/10 of the track. He has 45 meters left to run. What is the total length of the running track?

First step: 3/5+1/10=7/10 (The run way as a fraction)

Second step: 10/10-7/10=3/10 (The rest of the way as a fraction)
Third step: The third step is expected from the students

Example 3. Bilge spends first 3/4, then 1/8 of her money. If 20 Turkish liras is left, how much money did she have at the beginning?

First step: 3/4+1/8=7/8 (Total spent money as a fraction)

Second step: The second step is expected from the students.
Third step: The third step is expected from the students.

Data Analysis

First of all, data were prepared for analysis, and then, mean, standard deviation, skewness and kurtosis values calculated as descriptive statistics. Kruskal Wallis H test (when the distribution was not normal) and ANCOVA test (when the distribution is normal) were used to find the differences among the groups in terms of mathematics performance. Significance level was defined as at least .05.

Results

According to pre-assessment of fraction tests, both four operations part and fraction problem part scores showed that the four groups were not significantly different prior to the intervention. There were no significant differences between their mean scores of four operations part ($F(3.63)=0.75$, $p>0.05$) and fraction problems part ($F(3.63)=0.41$, $p>0.05$).

After the treatment, in order to answer the first research question “What are the relative effects of four different types of worked-out examples on students’ learning process, transfer and follow-up scores?”, learner performance across the four conditions was examined on each of the following dependent variables: (a) learning performance while examining worked-out examples (b) transfer test (c) follow-up test. Table 1 presents the means and standard deviations for each group on dependent measures.

Table 1. Means and Standard Deviations for Each Group on Dependent Measures

		Learning process	**Transfer**	**Follow-up**
Experimental Group 1 Worked-Out Examples N=19	M	36.32	5.42	19.13
	SD	11.18	3.94	11.62
	Adj. M		5.47	18.55
Experimental Group 2 Worked-Out Examples With Fading N=15	M	39.87	7.67	23.84
	SD	5.62	3.94	7.52
	Adj. M		7.6	24.2
Experimental Group 3 Worked-Out Examples With Self-Explanation Prompts N=18	M	39.61	9.39	24.39
	SD	8.29	4.99	9.13
	Adj. M		9.55	24.85
Experimental Group 4 Fading Worked-Out Examples With Self-Explanation Prompts N=15	M	44.83	9.83	29.75
	SD	4.69	3.76	8.04
	Adj. M		9.6	29.23

As it is seen in Table 1, the performance of the groups on fraction problems was measured during the learning process, after the intervention (transfer) and one week after the intervention (follow-up). In all cases, the performance of experimental group four (fading worked-out examples with self-explanation prompts) was higher than the other experimental groups. Moreover, experimental group one (worked-out examples) had a lower score than the other experimental groups. In the following, all cases were examined step by step to analyze the significant differences among the groups.

Analysis of Learning Process Measure

Since the data were not normally distributed, in order to analyze the differences in fraction problem performance among the groups while examining worked-out examples, the Kruskal Wallis H test was conducted.

Kruskal-Wallis H test showed that there was no significant difference in performance scores among the different worked-out example groups (χ^2=6.89, $p>0.05$).

Table 2. The Results of Kruskal Wallis Test of Learning Performance According to Worked-out Groups

Groups	N	Mean rank	df	χ^2	*p*
E.G. 1 Worked-Out Examples	19	27.05			
E. G. 2 Worked-Out Examples With Fading	15	30.33			
E. G. 3 Worked-Out Examples With Self-Explanation Prompts	18	32.06	3	6.89	0.08
E.G. 4 Fading Worked-Out Examples With Self-Explanation Prompts	12	44.50			

Analysis of Transfer Measure

With respect to treatment effects on transfer performance, ANCOVA test was used to analyze the pretests of fractions.

Apart from the large main effect of the pretests, the intervention had a significant main effect on transfer performance (F(3.61)=3.74, $p=0.01$, η^2=0.12). The transfer scores of the students in experimental group 4, who were given fading worked-out examples with self-prompts, and the students in the experimental group 3, who were given worked-out examples with self-explanation prompts, were higher than the scores of students in the first group, which were given worked-out examples. Partial eta-squared values, independent of the pretest scores from different groups, explain 12% of the variance in the transfer scores.

Table 3. ANCOVA with Dependent Variable Transfer Test Scores, Fixed Factor Pretest Scores

Source	Type III Sum of Squares	df	Mean Square	F	Partial Eta Squared
Model	261.29	5	52.26	2.98*	.21
Problem	47.28	1	47.28	2.69	.04
Grup	196.48	3	65.49	3.74*	.12
Error	1016.95	58	17.53		
Total	5263.00	64			
Total	1278.23	63			

* $p<0.05$

Analysis of Follow-up Measure

With respect to the treatment effects on follow-up performance, ANCOVA test was used to check the pretests of fractions. Apart from the large main effect of the pretests, the intervention had a significant main effect on the follow-up performance ($F_{(3,61)}$=3.26, $p=0.03$, η^2=0.14). The follow-up scores of the students in experimental group 4, who were given fading worked-out examples with self-prompts, were higher than the scores of the students in the first group, which were given worked-out examples. Partial eta-squared values, independent of pretest scores from different groups, explain 14% of the variance in the transfer scores.

Table 4. ANCOVA with Dependent Variable Follow-up Test Scores, Fixed Factor Pretest Scores

	Type III Sum of Squares	df	Mean Square	F	Partial Eta Squared
Model	1188.23[a]	5	237.65	2.99*	.21
Problem	111.99	1	111.99	1.41	.02
Grup	775.59	3	258.53	3.26*	.14
Error	4603.77	58	79.38		
Total	42656.00	64			
Corrected Total	5792.00	63			

* $p<0.05$

After answering the first research question, the second research question “Does using self-prompts produce more favorable learning outcomes than not using self-prompts on students learning process, transfer and follow-up scores?” was analyzed. Third and fourth groups were combined and called as worked-out group that has self-prompts and first and second groups were combined and called as worked-out group that doesn’t have self-prompts. To check learning process performance, Mann Whitney U test was conducted. It was found that there was no significant difference between these two groups (U=374, $p>0.05$) on learning process measure. For transfer performance, in order to compare the worked-out example groups that have self-prompts with groups that do not have self-prompts, ANCOVA test was conducted. It was found that the performances of students who had worked-out examples with self-prompts were significantly higher than the other students (F(1,61)=9.16, $p=0.004$, η^2=0.13). Again ANCOVA test was used for the follow-up test to compare these two groups and it was found that the performance of students who had worked-out examples with self-prompts were significantly higher than the other students on the follow-up questions ($F_{(1,61)}$=4.33, *p=0.04,* η^2=0.07).

Lastly, the third research question "Does using backward fading produce more favorable learning outcomes than not using backward fading on students learning process, transfer and follow-up scores?" was analyzed. Second and fourth groups were combined and called as worked-out group that has fading steps and first and third groups were combined and called as worked-out group that does not have fading steps. For learning process performance, Mann Whitney U test was conducted. It was found that there was no significant difference between these two groups (U=471, *p>0.05*) on learning process measure. ANCOVA test was conducted to compare these two groups according to transfer measure and it was concluded that there was no significant difference between students from groups that had worked-out examples with fading and students from groups without fading ((F(1.60)=2.09, *p=0.15*, η^2=0.03). Likewise, according to the follow up test, there was no significant difference between these two groups (($F_{(1,60)}$=3.13, *p=0.08*, η^2=0.04).

Discussion

The primary purpose of this study was to determine the relative effects of four different types of worked-out examples (worked-out examples, worked-out examples with self-explanation prompts, backward fading worked-out examples and fading worked-out examples with self-explanation prompts) on math performance of novice middle school students. Since recent studies show that worked-out examples are unnecessary for students who have relevant knowledge (e.g. Bokosmaty, Sweller and Kalyuga, 2015), only novice students were selected for the current study. These students were observed in three ways: performance on learning process; performance on transfer test, and performance on follow up test.

According to learning process measure that consists of questions that were answered by the students during the intervention, there was no difference between four groups. Since questions with similar solutions were given to the students, they were probably able to solve them by looking at the given solutions. Although there was no difference between these four groups, the minimum mean score among these groups was 36.32 out of 50. Therefore, it can be said that all groups are successful in learning process measure. The main reason for this result may be not having a control group in the study. A similar result was observed in Efklides, Kiorpelidou and Kiosseoglou's (2006) study that examine the relative effects of four kinds of worked-out examples (simple solution, textbook solution, sub-goals solutions, examples-practice solution) with a control group. They observed these five groups while performing a task. According to their results, worked-out examples improved the performance in all experimental groups compared to the control group that received no such intervention. However, the main purpose of learning is generalization and transfer of knowledge, so it is important to examine the long term effects and transfer of knowledge rather than the short term effects.

According to the results of the transfer test, students from both worked-out examples with self-explanation prompt group and fading worked-out examples with self-explanation prompt group were more successful than students from worked-out examples group. Similar results were observed in the follow-up test. However, this time only students from fading worked-out examples with self-explanation prompt group were more successful than students from worked-out examples group. Although fading worked-out examples are not effective alone, its combination with self-prompt explanation is effective in both short term and long term. This result is consistent with the findings of Atkinson, Renkl and Merrill (2003). They conducted two studies to study the effects of self-explanation prompts and fading worked-out example steps. According to their results, backward fading with self-explanation prompting has a statistical and practical effect on probability calculation problems. They stated that this combination appears to influence the quality of example processing without increasing learning time.

In addition, when groups are reorganized according to whether they had self-explanation prompt or not, the students from groups who have self-explanation prompts were more successful in both transfer test and follow-up test. On the other hand, there were no differences between groups who had backward fading in their worked-out example and groups with no backward fading. This finding is inconsistent with Renkl, Atkinson, Maier and Staley (2002)'s study that was conducted to test the effectiveness of a fading (backward and forward) procedure against the traditional method of using example-problem pairs. They conducted three studies to compare them. According to their results, only backward fading procedure fostered both near and far transfer performance. As far as it is indicated in the study, self-explanation prompts were more effective than both fading worked-out examples and worked-out examples. The reason behind this may be the fact that both worked-out examples and fading worked-out examples did not provide sufficient process information. Moreover, both worked-out examples with self-prompt explanations with or without fading gave information about how to solve the problem by self-explanation prompts.

The results of this study point out the importance of self-prompt explanation. The importance of self-explanation was also indicated in literature. Studies show that while solving problems, especially novice students do not engage themselves in self-explanation (Renkl, 1999). On the other hand, self-explanation increases cognitive activity (Bude, Van de Wiel, Imbos and Berger, 2012). Cognitive activity enhances the construction of knowledge, so it improves the performance of the learner (Chi, 1996). In addition to that, self-explanations reduce extraneous cognitive load, so students' performance can improve considerably. (Bude, Van de Wiel, Imbos and Berger, 2012; Renkl, 1997, 1999; Renkl, Stark, Gruber and Mandl, 1998). Furthermore, according to Crippen and Earl (2007) who used web-based worked-out examples, the combination of a worked-out example with a self-explanation prompt improves not only performance but also problem solving skills and self-efficacy.

The instructional model behind the learning environment that combines worked-out examples with self-explanations prompts is cognitive apprenticeship (Atkinson, Renkl and Merrill, 2003). The concept of a cognitive apprenticeship-defined as "learning through guided experience on cognitive and metacognitive, rather than physical, skills and processes" by Collins, Brown and Newman, (1989, p.427) -has its roots in social learning theories (Atkinson, Renkl and Merrill, 2003). Especially at the initial phases of learning, expert demonstration (modeling) and guidance (coaching) are important educational activities of cognitive apprenticeship. Learners work with more experienced learners. They first observe them, and then actively participate in the activities (Collins, Brown and Newman, 1989, p.814). This approach is a characteristics of Vygotsky's (1978) "zone of proximal development", in which problems or tasks that are slightly more challenging than they can handle on their own are provided to learners (as cited in Atkinson, Renkl and Merrill, 2003).

In short, the results of this experiment clearly indicate that the use of self-explanation prompts in combination with backward fading fosters learning in both long term and short term. In particular, this combination appears to assist novice learners in solving problems that are not only similar to the ones provided during instruction, but also structurally different from the instructional material. A major advantage is that learning from backward fading worked-out examples using self-explanation prompt can be easily implemented and is compatible with ordinary framework conditions in schools with very simple means such as worksheets or homework. In addition, since examples drawn from school textbooks do not often include all the reasons why a certain step in the solution was performed, the solutions of questions can be presented this way.

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