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The effect of instructional materials developed in relation to decimal fractions on success

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Abstract

This study aims to examine the effect of instructional materials developed on the basis of 4 stage constructivist model on the success of 6th grade students in the subject of decimal fractions. For this purpose, a worksheet on decimal fractions, a conceptual change text and an analogy map were developed. These instructional materials were administered to 62 students selected from two different 6th grade classes in a primary school in Trabzon in 2008-2009 school year. Semi-experimental method was used in this study. At the end of the study, it was seen that the instructional materials developed increased students' success.

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1. Introduction

Misconceptions are certain behaviors stemming from the false beliefs and experiences of the individual (Moralı, Köroğlu & Çelik, 2004). New knowledge is constructed upon old ones and therefore previous experiences may lead to incorrect comprehension of new concepts (Baki, 1998). Thus, previous knowledge is very important for meaningful and permanent learning. Solution to a problem or doing an operation may occasionally seem logical to the pupils according to their previous knowledge and they may not know that it's mathematically invalid. This may lead to misconceptions (Baki & Bell, 1997).

Traditional teaching methods are considered to be one of the important factors leading to formation of misconceptions (Lawson & Thompson, 1988). Student's perception means nothing when learning is considered as the transfer of knowledge as in behaviorist approach. The teacher will somehow transfer what is regarded to be correct. Misperceptions are permanent and powerful and they affect the way students view events therefore attempting to remedy them using direct instruction makes no use and still worse, may sometimes lead to new misconceptions (Özmantar, Bingölbali & Akkoç, 2008).

According to constructivist view, students give meaning to newly encountered situations based on their previous experience and preliminary knowledge (Çalık, 2006). Several models were developed for constructivist approach which argues that students give meaning to and grasp new situations by utilizing their previous experiences and

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preliminary knowledge. One of these models is the 4-stage constructivist model developed by Baki (2008). This model consists of the stages of introduction-arousing curiosity, explaining-discovery, abstraction and evaluation. The study of Yıldız (2010) may be referred to for more detailed information about this 4-stage constructivist model. Teacher may bridge the gap between the attainments and students' existing levels by preparing various instructional materials for a new unit or subject (Ersoy, 2001). Thus, interactive learning processes such as the 4-stage constructivist model in which students are at the center and more effective in many ways should be preferred to more teacher centered approaches.

Decimal fractions are among the fundamental topics of mathematics and they form a basis for many other topics. (Baki & Pırasa, 2007). Decimals are one of the important concepts in mathematics because they can be read and written as in decimal system, they facilitate arithmetic operations and they are commonly used in measurement of length, area and in other fields of daily life (Baykul, 2001). Therefore, studying decimal fractions is important in terms of teaching mathematics (Baki & Pırasa, 2007).

Since studies based on a certain learning approach might give more desired outcomes (Kurt & Akdeniz, 2002; Niaz, 2001), materials should be prepared considering current learning approaches. Many studies on mathematics education are not explicitly based on a certain learning approach but instead they either use worksheets (Ev, 2003; Özdoğan; 2005), analogy (Richland, Holyoak, & Stigler, 2004; Turgut, 2007) or conceptual change texts (Toka, 2001). It should be noted that frequent use of worksheets may make students bored, preparing a program or textbook involving all misconceptions of students for conceptual change texts is very arduous (Dole, 2000) and frequent use of analogies is not very effective (Huddle, White & Rogers, 2000). Therefore, it's believed to be complementary using analogy, conceptual change text and worksheets within the framework of the 4-stage constructivist model. Bearing this in mind, this study explores the achievement of 6th graders in the topic of decimal fractions by preparing a worksheet according to analogy and conceptual change text within the framework of 4-stage model and using it in / as real classroom setting.

2. Method

In this study, a quasi-experimental method was used. A pre- and post-test, control group experimental design was preferred. One of the existing classes was assigned randomly as intervention group and another as control. In control group, the instruction was based on textbook whereas intervention group was instructed with an approach based on the 4-stage constructivist model.

2.1. Participants

The study was conducted with two different 6th grade classes in a public elementary school in Trabzon during the spring term of 2008-2009 school year. Total number of participants was 62. Of these students, 32 were in control and 30 were in intervention group.

2.2. Data collection tools

The data in this study are collected using the performance test and instructional materials (worksheet, conceptual change text and analogy map) developed for the subject of decimal fractions. In the first stage of the development of student materials, preliminary interviews were conducted with primary mathematics teachers about decimal fractions and their instruction. As a result of the interviews with teachers, students were determined to have difficulties in comprehending decimal fractions. So, it was understood that effective materials in teaching decimal fractions are needed. To meet this need, instructional materials were developed by the researchers after relevant literature review. Developed materials were then examined by two mathematics educators and two mathematics teachers. Teachers and academicians confirmed that the materials may appropriately serve the aim of the study.

2.2.1. Performance test

The performance test regarding decimal fractions was developed considering student attainments included in the new 6th grade mathematics curriculum, teacher views and the misconceptions reported in the literature. The test contains total 10 multiple choice questions with 2 stages involving concepts “*Comprehension of the meaning of decimal fractions*”, “*Naming the places of decimal fractions*”, “*Comparing decimal fractions*”, “*Ordering decimal fractions*”. The items in the test were prepared considering the misconceptions such as “*Ignoring the comma*”, “*Overestimating or underestimating decimal fractions with many places*”, “*Not regarding zero as a place value*”, “*Thinking that zero has no meaning*”, “*Incorrect naming of the places after comma*”, “*Perceiving comma as a symbol separating two distinct numbers*”.

The questions of the performance test were checked by 2 elementary mathematics teachers and 2 academicians working in the field of mathematics education in order to provide content validity. Moreover, by referencing to teachers’ views and the 6th grade mathematics curriculum of National Ministry of Education, it was sought to fit the questions to the levels of 6th grade students. In order to calculate the reliability of the test, a pilot study was conducted. With this practice, it was investigated whether students had any difficulty in understanding the questions in the test and the necessary time to answer the test. Total 45 students studying in 6th grade classes of a primary school in Trabzon participated in the pilot study. As a result of the pilot study, reliability coefficient and discrimination index for every item included in the test are calculated using appropriate formulas. As a result of these calculations, the items whose discrimination index is under 0.30 are excluded from the study. The excluded items are replaced with items related to the same attainment. The Cronbach’s alpha reliability coefficient of the test was found as 0.85 by using SPSS 15. Furthermore, the Cronbach’s alpha reliability coefficient was calculated as 0.89 by taking the pre-test results of real study. This may be due to the adjustments made in the test. Considering the modifications made in the pilot study, the performance test was applied to study group, as a pre-test a month prior to and as a post-test immediately after the intervention.

2.2.2. Instructional materials

Instructional materials were divided into two parts as teacher material and student materials for ease of use. The teacher material includes the prepared lesson plan prepared related to decimal fractions and student materials include the worksheet, analogy map and conceptual change text.

2.3. Implementation of instructional materials

This study was conducted on the subject of decimal fractions, in which students have difficulties and misconceptions. The study continued for 5 weeks. The pre-tests were conducted 2 weeks prior to and post-tests were conducted 2 weeks after the intervention. The intervention went on 4 class hours. The subject of decimal fractions was instructed in the control group by sticking to textbook and misconceptions were not addressed in the classes. With the experimental group, the subject is taught using worksheets, analogy maps and conceptual change texts and the students worked as pairs during the instruction. The teacher tried to evoke conflicting situations in the minds of the students in the experimental group and to show that their previous knowledge is insufficient. The study of Yıldız et al. (2010) may be referred to for more detailed information about how the instructional materials were implemented.

2.4. Data analysis

The evaluation criteria used to analyze the 2-stage multiple choice questions in the performance test and the scores corresponding to each criterion are shown in Table 1 (Karataş, Köse & Coştu, 2003).

Table 1. The evaluation criteria used to analyze the 2-stage multiple choice questions and the corresponding scores

Explaining	Evaluation Criteria	Scores
Both the multiple choice and explanation parts are correct	Correct Answer - Correct Justification	4
Multiple choice part is correct but explanations are insufficient	Correct Answer - Partially Correct Justification	3

Multiple choice part is wrong but explanations are correct	Wrong Answer - Correct Justification	3
Multiple choice part is correct but there's no explanation	Correct Answer - Wrong Justification	2
Multiple choice part is wrong and there are alternative concepts in the explanations	Wrong Answer - Wrong Explanation	1
Multiple choice part is wrong and explanations are irrelevant	Blank Answer - Irrelevant Explanation	0

Each question in the performance test was scored according to the criteria above. After this scoring, students' total scores from the pre- and post-tests were analyzed using SPSS 15.

3. Results and Discussion

In this part, the data obtained from the performance test were analyzed using independent t-test and the results were presented in tables.

The answers of the students in both the experimental and control groups were scored according to the criteria mentioned above. As a result of this scoring, independent t-test was performed to determine whether a significant difference exists between the pre-test scores of the students in experimental and control groups and the results were given in Table 2.

Table 2. Independent t-test results concerning the pre-test scores of the students

Groups	Tests	N	Mean	Sd	df	t	p
Experiment	Pre-Test	30	10,550	2,552	60	7,76	0,230
Control	Pre-Test	32	11,436	1,803			

No significant difference at the significance level of $p > 0.05$ was found between the pre-test scores of intervention and control groups (Table 2). This result indicates that there's no significant difference between the pre-test scores of the intervention and control groups.

Independent t-test was performed to determine whether a significant difference exists between the post-test scores of the students in experimental and control groups and the results are given in Table 3.

Table 3. Independent t-test results concerning the post-test scores of the students

Groups	Tests	N	Mean	Sd	df	t	p
Experiment	Post-Test	30	31,750	2,629	60	8,580	0,000
Control	Post-Test	32	18,693	3,130			

A significant difference at the significance level of $p < 0.05$ was found between the post-test scores of intervention and control groups (Table 3). An increase was found in the mean scores of the experimental and control groups after instruction. But this increase was found to be more significant in the experimental group. The implemented activities and materials were found to increase students' achievement and be effective in helping them to understand decimal fractions in the experimental group. This finding aligns with the results of the studies by Çalık (2006), Kurt & Akdeniz (2002) and Niaz (2001) which suggested that better results may be obtained with studies that are based on a certain learning model.

4. Conclusion and recommendation

The aim of this study was to investigate the effect of instructional materials developed on the basis of 4-stage constructivist model on the success of 6th grade students in the subject of decimal fractions. With this aim, a worksheet, an analogy map and a conceptual change text on the subject of decimal fractions were developed and applied to the students. At the end of the study, it can be argued that instruction of mathematics using the materials developed according to 4-stage constructivist model might be effective in increasing students' achievement. When it is considered that materials developed keeping a given model in mind lead to better results and the 4-stage constructivist model has a small number of stages and it is applicable, it is recommended that it should be used in mathematics lessons.

Since prepared instructional materials prepared based on 4-stage constructivist model may be effective in increasing students' success, it's recommended to prepare instructional materials such as worksheet, analogy map and conceptual change text that may help remedying / removing misconceptions. Since correct perception of basic subjects of mathematics such as decimal fractions is very important, the number of this kind of studies in mathematics education is expected to increase.

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