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The effect of conceptual change approach on 9th grade students' achievement

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Abstract

This study investigates the effect of materials developed based on conceptual change approach on 9th grade students' achievement in the subject of fractions. With this aim, a worksheet, conceptual change text and a two-stage performance test on the subject of fractions were developed. Quasi-experimental research model was used in the study. Following this model, the fractions were taught with traditional method in the control group and it was taught using worksheets and conceptual change texts in the experimental group. The performance test was applied as pre- and post-tests to total 46 students studying at two different 9th grade classes of a high school in Trabzon during 2008-2009 school year. The results of the study revealed that the instructional materials increased students' success in the experimental group. Therefore, it's recommended to use the materials developed during the course in mathematics classes and to develop similar materials for other subject matters.

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1. Introduction

Recent research indicates that learning takes place as a result of the interaction between pupils' existing knowledge and new knowledge (Kabapınar, 2003). Pupils organize new knowledge by constructing their own knowledge in their minds related to a certain object, event, phenomenon or concept perceived from the outer world by sense organs or at least by interpreting the truth based on their previous experiences (Jonassen, 1994). The knowledge possessed by the pupils leads to misconceptions when it's scientifically different from true knowledge. Pupils construct knowledge of new concepts on their previous knowledge. Their previous knowledge may sometimes lead to misconceptions in learning new concepts. 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). In order to remedy misconceptions and provide meaningful learning, existing knowledge should be reviewed and changed to accommodate new information (Smith, Blakeslee & Anderson, 1993). Many teaching approaches have been developed for this aim. One of these approaches is conceptual change approach.

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In conceptual change approach which is developed based on constructivist learning model and is frequently used in learning-teaching environments recently, students' existing knowledge are given priority and instructional activities are determined based on these knowledge (Stofflett, 1994). Conceptual change approach represents an alternative approach which encourages students to make transition from misconceptions, i.e. their non-scientific knowledge to scientifically accepted knowledge. This approach is built upon the assimilation, organization and accommodation principles (Wang & Andre, 1991). According to the conceptual change approach developed by Posner, Strike, Hewson and Gertzog (1982) the conceptual change process is addressed in two stages. First one is concerned with the accommodation in the existing knowledge of the students and the other one is concerned with new accommodations in newly confronted knowledge. In the first stage, students are expected to realize during the solution to a new problem that their existing knowledge is insufficient. When the insufficiency of existing concepts is felt, the student will experience a conflict between his/her previous knowledge and new knowledge and as a result a mental conflict will arouse and the student will be ready for conceptual change. In the second stage following this one, student should find the new knowledge understandable, logical and efficient. This approach suggested by Posner et al. to help students remedy their misconceptions includes instructional strategies such as conceptual change texts, analogy and use of models (Chambers & Andre, 1997).

In order to enhance conceptual change, conceptual change texts are frequently used among the strategies mentioned above. In conceptual change texts, the misconceptions the students might have are written and the insufficiency or error in these concepts is emphasized. The teacher may add to the text the learning difficulties faced in this subject according to his/her experiences. Students can be persuaded in this way that their beliefs are wrong and then correct concepts are explained using necessary scientific explanations in a way comprehensible by the students. By working on the texts individually or in groups, students compare their beliefs with those given in the text and they reflect on it. This way, an attempt is made to remedy student's wrong belief with the correct one. Conceptual change texts are generally distributed to the students during instruction and the students are asked to examine the texts individually or in groups. After ensuring that everyone has read the text, students are allowed to acquire the correct idea by class discussion (Çepni, 2008).

Fraction concept is one of the important basic concepts in mathematics (Köseoğlu, 2005). Learning and perceiving new concepts are difficult or even impossible unless deficient learning and misconceptions in basic concepts are corrected (Yılmaz, 2007). There are some difficulties in understanding fractions as well as its being an important concept in mathematics (Ardahan & Ersoy, 2002; Başgün & Ersoy, 2000; Davis, 2003; Haser & Ubuz, 2000; Post, 1989). The main reason of these difficulties is the structure of fractions and how it's taught (Aksu, 1997). In researches on learning fractions, students' difficulties and misconceptions may be classified. The most common misconceptions are: Perceiving the symbolic representation of a/b not as a single number but as two distinct numbers having different meanings and values, adding the numerators and denominators of fractions independently and showing as numerator and denominator, ordering fractions (from smaller to larger or vice versa) as in natural numbers, and failing to show the point on the number line corresponding to a given simple or proper fraction (Ersoy & Ardahan, 2003). There are many other misconceptions regarding four operations in fractions (Mack, 2000; Piel & Green, 1994; Rizvi & Lawson, 2007; Soyly & Soyly, 2005).

When studies on mathematics education are examined, it can be seen that these studies determine the misconceptions in various subjects of mathematics, but few studies concentrated on developing materials remedying/reducing these misconceptions (Richland, Holyoak & Stigler, 2004; Toka, 2001; Turgut, 2007). Developing materials for remedying/reducing misconceptions are as important as diagnosing the misconceptions students have and analyzing these in detail. This study investigating the effect of the developed instructional materials on student success in the subject of fractions which form the basis of many subjects is thought to contribute to bridge the gap in this field.

2. Method

Quasi-experimental research model was used in the study. In experimental models, the data to be observed are produced directly under the control of the researcher with the aim of determining cause-effect relationships (Karasar, 2008). In some cases, it may be impossible to randomly assign individuals to experimental and control groups. Quasi-experimental research model is used in these cases. In this model, individuals are not randomly

assigned to intervention and control groups. Quasi-experimental research model is also used when the existing educational system does not allow randomly assigning students to groups (Çepni, 2007).

2.1. Participants

The study group consists of total 46 9th grade students studying in two different classes of a high school in Trabzon during 2008-2009 school year. Since every class in this school consists of 23 pupils, the experimental and control groups also consisted of 23 pupils.

2.2. Data collection tools

The data in this study are collected using the performance test and instructional materials (worksheet and conceptual change text) developed for the subject of fractions. In the first stage of the development of student materials, preliminary interviews were conducted with secondary mathematics teachers about fractions and their instruction. As a result of the interviews with students, students were determined to have difficulties in comprehending fractions. So, it was understood that effective materials in teaching 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 fractions was developed considering student attainments included in the new 9th grade mathematics curriculum, teacher views and the misconceptions reported in the literature. The test comprises of 15 two-stage multiple choice questions made up of attainments as “Explains the meaning of a fraction, types of fractions and equivalent fractions.”, “Orders multiple rational numbers in a chain of inequality and show these numbers on the number line.”, “Makes addition, subtraction, multiplication and division operations in rational numbers set and explains their properties.”. 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 50 students studying in 9th grade classes of a high 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 α -reliability coefficient of the test was found as 0.92 by using SPSS 15. 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 lesson plan prepared related to fractions and student materials include the worksheet and conceptual change text.

2.3. Implementation of instructional materials

This study was conducted on the subject of fractions, in which students' have difficulties and misconceptions. The study continued for five weeks. The pre-tests were conducted two weeks prior to and post-tests were conducted two weeks after the intervention. The intervention went on four class hours. The subject of fractions was taught to students in the control group using traditional method (direct instruction) and misconceptions were not addressed in the classes. With the experimental group, the subject is taught using worksheets 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. Then conceptual change texts were distributed to pupils in order to present new knowledge. The misconceptions are explicated in

these texts and correct knowledge is presented to the students with their justification. Finally, students evaluated their own performances and the instruction process.

2.4. Data analysis

The evaluation criteria used to analyze the two-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 two-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 above criteria. After this scoring, students' total scores from the pre- and post-tests were analyzed using SPSS 15.

3. Results

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 |
|--------------|----------|----|--------|--------|----|-------|-------|
| Experimental | Pre-test | 23 | 30.782 | 15.261 | 44 | 0.405 | 0.688 |
| Control | Pre-test | 23 | 28.956 | 15.337 | | | |

No significant difference was found between the pre-test scores of experimental and control groups ($p > 0.05$). This result indicates that there's no significant difference between the pre-test scores of the experimental 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 |
|--------------|-----------|----|---------|-------|----|-------|-------|
| Experimental | Post-test | 23 | 47.826 | 2.629 | 44 | 3.003 | 0.004 |
| Control | Post-test | 23 | 35.8261 | 3.130 | | | |

A significant difference was found between the post-test scores of experimental and control groups ($p < 0.05$). 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.

4. Conclusion and Recommendation

The aim of this study was to investigate the effect of materials developed based on conceptual change approach on 9th grade students' achievement in the subject of fractions. With this aim, a worksheet and conceptual change text on the subject of fractions were developed and applied to the students. The results of the study revealed that the conceptual change approach outperformed traditional teaching in students' understanding of the subject of fractions. Based on this result, it can be argued that instruction of mathematics using the materials developed according to conceptual change approach might be effective in increasing students' achievement.

Since instructional materials prepared based on conceptual change approach may be effective in increasing students' success, it's recommended to develop two-stage tests that will determine students' misconceptions and to prepare instructional materials such as worksheets, analogy map and conceptual change texts that may help remedying/removing misconceptions. Since correct perception of basic subjects of mathematics such as fractions is very important, the number of this kind of studies in mathematics education is expected to increase.

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