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The effect of instructional materials on decimal fractions to the conceptual change

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Abstract

This study investigates the effect on conceptual change of instructional materials about "decimal fractions" developed by adopting 4 stage constructivist learning model. The study was conducted with 30 students 6th grade at a public elementary school in Trabzon during the spring term of 2008-2009 school year. Case study method was used in the study. The clinical interviews were made with 6 students just before the application and one month later. When the students' responses to the interview questions after the application were investigated, it was identified that the number of students' responses containing misconceptions was decreased at the end of the study.

Keywords: Primary mathematics, decimal fractions, misconception, conceptual change, mathematics education

1. Introduction

As mathematics is a cumulative branch of science, each concept learned is a step towards a new concept. Thus, a difficulty or incorrect information learned during a previous concept may cause difficulties while learning following concepts (Tirosh & Graeber, 1991). When students do not learn a concept in mathematics well or leave something missing, they face some problems and these problems may affect their future education. So, flaws in students' learning may appear. If not corrected, these flaws may become misconceptions. In mathematics, it is important that misconceptions must be determined and ways to solve them must be found because prior concepts and information form a step towards following ones. Thus, a misconception regarded as unimportant in mathematics will cause misconceptions in following subjects (Yılmaz, 2007).

Like many other subjects in mathematics, decimal fractions is a field in which misconceptions are frequently observed. Decimal fractions is 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). Decimal fractions is one of the subjects which is difficult to understand on the part of students due to their abstractness. So, it has been a subject for research in a lot of domestic and foreign studies (Ardahan & Ersoy, 2002; Baki & Bell, 1997; Cankoy, 1998, 2000; Ersoy & Başgün, 2000;

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Seyhan & Gür, 2004; Steinle, 2004; Steinle & Stacey, 1998; Sulak & Cihangir, 2000). In these studies, several misconceptions have been determined such as disregarding the decimal point (Seyhan & Gür, 2004) or regarding it as a separation between two different numbers (Cankoy, 1998, 2000; Seyhan & Gür, 2004), assuming that multi-digit decimal fractions are larger / smaller (Cankoy, 1998, 2000; Seyhan & Gür, 2004; Steinle & Stacey, 1998; Sulak & Cihangir, 2000), supposing that zero reduces the value of a number or has no effect (Seyhan & Gür, 2004), not naming the digit on the decimal part of the number correctly (Seyhan & Gür, 2004) and misunderstanding the digit value in decimal fractions (Ardahan & Ersoy, 2002; Baki, 2008; Baki & Bell, 1997; Sulak & Cihangir, 2000).

Misconceptions in decimal fractions usually occur because of incorrect instruction methods and philosophies (Seyhan & Gür, 2004). Although learning is conceived as structuring of information in learner's mind, learning is often based on interactions with other individuals. Constructivist learning view suggests that, pupils need learning experiences to construct their new knowledge with their existing ideas (Baki, 2008). To that end, anologies, a conceptual change text and a worksheet were prepared and the effect of these materials on sixth grade students' understanding was examined.

2. Method

Case study method was used in this study. Case studies enable in depth investigation of a single or a number of cases, phenomena or events with a limited sampling (Çepni, 2007). During this process, the setting, individual or processes are investigated holistically and the roles and relations draw the main focus (Yıldırım & Şimşek, 2005).

2.1. Participants

The study was conducted with 30 students at 6^{th} grade at a public elementary school in Trabzon during the spring term of 2008-2009 school year.

2.2. Data collection tools and process

The data in this study are collected using the clinical interview and instructional materials (worksheet, conceptual change text and anology map) about "decimal fractions" developed by adopting 4 stage constructivist model. In this part, information on clinical interviews will be given instead of information on how teaching materials were developed (for further information on this issue can be obtained from the study by Yıldız et al. (2010)).

Clinical interviews were used in this study due to the fact that they provide the opportunity to examine a subject in depth and they also give students the chance to speak more freely. A pre-interview was done with students in this study to determine their prior knowledge before the main application. Also, another interview was done with the same students to examine the effect of the activities and materials developed and to determine the changes in students' ideas. The same questions were asked to the students in the pre-interview and post-interviews. In these interviews, a total of six questions were asked to the students about their misconceptions on decimal fractions. The interviews, which lasted about 30-35 minutes, were recorded with a tape-recorder. While the interview questions were being prepared, the literature on decimal fractions is taken into account along with opinions from two mathematics teachers and two mathematics educators. Six of students interviewed were chosen among students with high, average and low mathematics grades. Ethically, these students were coded as "S1, S2, S3, S4, S5 and S6".

2.3. Data analysis

In the analysis of the interviews, written transcripts were produced by listening to the recorded interviews. During this analysis, the researchers' comments and the participants' irrelevant replies were taken off instead of taking all the words individuals uttered. Then, rest of the information was analysed according to their similarities and presented in tables. In addition, authentic and original ones among students' replies were reported to serve as models.

3. Results

Students' answers to the question "What do you understand when decimal fractions are mentioned?" are as in Table 1.

Table 1. The understanding of students regarding decimal fractions

Given Answers	Pre-Interviews	Post-Interviews
Numbers that are separated by point.	S1, S2, S3	S1
Numbers that have integer and fraction parts.	S4, S6	S2, S4, S6
Numbers with units digit, tens digit and tenths.	S5	S3, S5

Note: In tables 1st, 2nd , 3rd , 4th , 5th , 6th , 7th and 8th the expressions with concept faults are written in *italic* font.

In pre-interviews, it was seen that some students (S1, S2, S3) see decimal fractions as 2 numbers separated by points while in post-interviews it was observed that the ideas of all students except one (S1), changed positively. While S2 answered the question in pre-interview as "*Separated numbers by points such as 13,5"* while in post-interview he answered as "*A single number such as 2.5 TL having integer and fraction parts".*

The answers of students to the question "*What is the purpose of decimal point? Can you explain?"* are given in Table 2.

Table 2. Answers regarding the purpose of decimal point

Given Answers	Pre-Interviews	Post-Interviews
It separates two numbers from each other.	S1, S2, S3	S1
It shows that the given number is a decimal fraction.	S5	S3, S5
It separates the integer and fraction parts.	S4, S6	S2, S4, S6

It can be seen that all students except S1, S2 and S3 correctly answered the question about the purpose of decimal point in pre-interview. In the post-interview all students except S1 gave answers without misconception. S_3 answered this question in pre-interview as *"We use it to separate the numbers from each other."* While in post-interview he answered as "*It shows us that the number is a decimal fraction.*".

The answers of students to the question *"Can we neglect the zeros in 0,05 decimal fraction? Why?"* are given in Table 3.

Table 3. The answers to the question whether we can neglect the zeros in a decimal fraction or not

Given Answers	Pre-Interviews	Post-Interviews
Zeros can be neglected.	S1, S4	-
If we neglect the zeros, the decimal fraction becomes a natural number.	S2, S3, S5, S6	S1, S2, S3, S4, S5, S6

It can be seen that 2 students (S1, S4) gave misconception answers to this question in the pre-interview however they answered the same question correctly in the post-interview. S4 answered this question as "*Zero describes nonexistence. Therefore it can be neglected."* in the pre-interview while he answered to the same question as *"If I delete the zeros it becomes a natural number. If I delete one zero it becomes 0,5 and if I delete 2 zeros it becomes 5 and the number changes.".*

The answers of students to the question *"Is 1,56 or 1,5 a smaller decimal fraction? Why?"* are given in Table 4.

Table 4. The answers of students regarding which of the given decimal fractions is smaller

Given Answers	Pre-Interviews	Post-Interviews
While there is 5 for the 5 in 1,5 to become 10, there is 44 for the 56 in 1,56 to become 100.	S5	-
The number is as big as the quantity of numbers after the point.	S1	S1
When we divide a whole into 56 pieces, magnitude of each piece is smaller than the pieces obtained when we divide the same whole into 50 pieces.	S2, S6	S6
There is hundreds digit in 1,56, there is not hundreds digit in 1,5.	S4	-
1,56 is closer to 2 when compared with 1,5.	S3	S3, S5
The 50 in 1,50 is smaller than the 56 in 1,56.	-	S2, S4

It can be seen that all students except 1 (S3), gave misconception answers to this question in the pre-interview however misconceptions of some of them (S1, S6) did not change after the post-interview while the opinions of some of them changed positively. S5 answered this question in pre-interview as "*In my opinion, 1,56 is smaller as the number on the right hand side being big does not show that number is big. While there is 5 for the 5 in 1,5 to become 10, there is 44 for the 56 in 1,56 to become 100. Therefore 1,5 is bigger. "* while in post-interview, he answered as "*1,5 is smaller. If we add one zero next to 1,5 it becomes 1,50. 1,56 is closer to 2. Therefore 1,56 is bigger.*

The answers of students to the question *"How does it effect to add a zero next to 6 in decimal fraction of 1,6? Why?"* are given in Table 5.

Table 5. The answers regarding the effect of adding a zero next to the fraction part of a decimal fraction

Given Answers	Pre-Interviews	Post-Interviews
As number of digits increases, adding a zero decreases the value of the number.	S2	S2
As number of digits increases, adding a zero increases the value of the number.	S1	-
It increases the number of digits but it does not change the value.	S3, S4, S5, S6	S1, S3, S4, S5, S6

It can be seen that S1 and S2 answered this question with misconception in pre-interview while all students except S2 answered correctly in the post-interview. While student S1 answered this question in pre-interview as "*It increases the number. Because the number of digits increase."* while in the post-interview he answered as "*It does not change. Because adding a zero next to it does not change it. It does not contribute to the value of the number. The digits of the number increases but the value does not change.".*

The answers of students to the question *"How do you name the digits of decimal fraction 2587,649? Why?"* are given in Table 6.

Table 6. The answers regarding the naming of decimal fraction digits

Given Answers	Pre-Interviews	Post-Interviews
Naming from right to left like natural numbers	S1, S2	S5
Naming from left to right in ascending order	S3	-
Naming integer and fraction parts separately	S4, S5, S6	S1, S2, S3, S4, S6

It can be seen that all students except S1, S2 and S3 answered this question correctly in pre-interview while all students except S3 answered without misconception in the post-interview. While S1 answered this question in pre-interview as "*I think the decimal fraction as a natural number and name it that way."* while in the post-interview he answered as "*I start naming the integer part of the decimal fraction from units digit and the fraction part from tenth digit."*

4. Conclusion and Recommendation

The conclusion is students have misconceptions such as thinking that decimal fractions with more digits are bigger or smaller, thinking that adding zero to a decimal fraction increases or decreases its value, naming the fraction digits of the decimal fractions wrong and confusing their comparison of numbers in the fraction part of the decimal fractions with sorting by fractions. This fact can be the reason of some misconceptions resisting to change (Ayas & Demirbaş, 1997). As a result we can reach to a conclusion that it is not easy to change these information that have a little tendency to change and are rigidly structured by the individual in his cognitive system (Lakatos, 1970). For this reason, it is suggested that teachers should take the pre-information and possible misconceptions of their students and use tests with 2 stages in their lessons.

In general, when the answers of the participants to the 6 interview questions are examined, it can be seen that the number of students giving misconception answers decrease after the study. The reasons of this case are considered as using different materials in teaching decimal fractions, correlating them with daily life, enriching the visual materials used and teaching the concepts by activities. Especially developed analogy being related with daily life can be considered to play the most important role on this. Digit names being correlated with military rank names are

very important in drawing attention to the analogy. For these reasons, mathematics lessons should be correlated with daily life as much as possible.

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