Available online at www.sciencedirect.com

ScienceDirect

Procedia Social and Behavioral Sciences 2 (2010) 3660–3665

Procedia
Social and Behavioral Sciences

WCES 2010

Development of materials in instruction of decimals according to constructivist approach

Cemalettin Yıldız[a] *, Adnan Baki[a], Mehmet Aydın[a], Davut Köğce[a]

[a]*Fatih Faculty of Education,Karadeniz Technical University,Trabzon,61100,Turkey*

Received October 29, 2009; revised December 7, 2009; accepted January 15, 2010

Abstract

Decimals are among the difficult subjects for the students because of its abstract nature. Therefore, the aim of this study is to develop instructional materials for students based on one of the four-stage models of constructivist approach related to the unit of "decimals". With this aim, a worksheet, analogy map and conceptual change text on the unit of decimals were developed. Case study method was used in the study. A pilot study was conducted with 32 6th graders studying in an elementary school in Trabzon in order to use the instructional materials in the classes more effectively and to test their feasibility. At the end of this preliminary study, the students were determined to find the materials effective, visual and interesting. Therefore, it's recommended to use the materials developed during the course in mathematics classes and to develop similar materials for other subject matters.

Keywords: Elementary mathematics; mathematics instructions; instructional materials; decimals; constructivist approach.

1. Introduction

According to constructivist view, students give meaning to newly encountered situations based on their previous experience and preliminary knowledge (Çalık, 2006). Although learning is considered as construction of perception of knowledge in the mind of the individual, in fact it's based on frequent interaction with other individuals. Constructivist learning view suggests that, pupils need learning experiences to construct their new knowledge with their existing ideas (Baki, 2008).

Several models were developed for constructivist approach which argues that students give meaning to and grasp new situations by utilizing their previous experiences and preliminary knowledge. One of these models is the four-stage model developed by Baki (2008). This model consists of the stages of introduction-arousing curiosity, explaining-discovery, abstraction and evaluation. This four-stage model will be explained in detail in the method section of this paper. 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 four-stage model in which students are at the center and more effective in many ways should be preferred to more teacher centered approaches.

Learning and perceiving new concepts are difficult or even impossible unless deficient learning and

* Cemalettin Yıldız. Tel.: +90-462-377-72-62
E-mail address: cemalyildiz61@hotmail.com

1877-0428 © 2010 Published by Elsevier Ltd.
doi:10.1016/j.sbspro.2010.03.569

misconceptions in basic concepts are corrected (Yılmaz, 2007). Number concept is one of the most important basic concepts in mathematics (Liebeck, 1984). It's therefore important for the students to perceive number concept. Since misconceptions at this point will directly affect all the subsequent mathematical concepts, number concepts should be constructed in pupil's mind clearly and precisely (Kaynak, Narlı, Köroğlu, Çelik & Alkan, 2000). 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). Although 'decimals' is an important concept in mathematics as mentioned before, they are among the difficult subjects for the students because of its abstract nature. Hence, it has featured as a research question in many national and international studies (Baki & Bell, 1997; Cankoy, 1998; Cankoy, 2000; Seyhan & Gür, 2004; Steinle, 2004; Steinle & Stacey, 1998).

Traditional teaching methods are considered to be one of the important factors leading to formation of misconceptions (Lawson & Thompson, 1988). Since studies based on a certain learning approach might give more desired outcomes (Niaz, 2001; Saka, 2001; Kurt & Akdeniz, 2002), materials should be prepared considering current learning approaches. Therefore, the aim of this study is to develop instructional materials for students related to the unit of "decimals", test the feasibility of these materials and correct their deficiencies. With this aim, a worksheet, analogy map and conceptual change text on the unit of decimals within the framework of the four-stage model were developed.

2. Method

Case study method was used in this study. Case studies enable in depth investigation and explanation of a single case pertaining to a certain phenomenon. This case might be any individual, event, group or an institution. Although case studies are widely used in both qualitative and quantitative inquiries, in the case of qualitative research they enable in depth investigation of a single or a number of cases, phenomena or events with a limited sampling (Çepni, 2007).

2.1. Participants

The study was conducted with 32 6^{th} graders studying in a public elementary school in Trabzon during the spring term of 2008-2009 school year (17 boys, 15 girls, average age 12 years).

2.2. Development of instructional materials

A worksheet (Appendix 1), conceptual change text (Appendix 2) and analogy map (Appendix 3) on the unit of decimals were developed as student materials. In the first stage of the development of student materials, unstructured interviews were conducted with five mathematics teachers about decimals and their instruction. As a result of the interviews with mathematics teachers, students were determined to have difficulties in comprehending decimals. So, it was understood that effective materials in teaching decimals 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.

2.3. Pilot implementation of instructional materials

The pilot implementation of the instructional materials was conduced in a 6^{th} grade class of an elementary school in Trabzon for two class hours. In the course of this pilot study, students worked as pairs. Some deficiencies were detected during the pilot study and they were corrected. Some properties of the stages followed during the implementation of the pilot study of the developed instructional materials and the actions meanwhile may be summarized as follows:

At *the introduction-arousing curiosity* stage, an orientation is made to draw students' attentions to the subject. Since students bring their previous experiences, ideas and misconceptions into the classes, students' preliminary knowledge and their misconceptions in this knowledge are revealed. This enables the teacher to prepare the

instructional activities according to the level of the students. At this stage, students' previous experience and preliminary knowledge about military life and ranks are checked and some explanations can be made if needed. Then, the question in the balloon is posed to the students and their views on the subject are obtained.

At *the explanation-discovery* stage, the experiences related to the intended concept are conveyed to the students. At this stage, various teaching methods are utilized to draw pupils' attentions to the subject. For this aim, a research problem is presented to the students and they are guided to think and interpret. At this stage, worksheet is handed out to the students and students are demanded to form pairs and to name their pair groups. After the pairs are formed, the instructions and explanations on the worksheet are followed. Students are asked to carry out the activities on the worksheet. The teacher walks among the groups, monitors and guides group discussions. Then, the teacher distributes the analogy map related with the study and explains this map.

Abstraction stage is the stage at which students compare newly confronted knowledge with their preliminary knowledge, question and modify it. The teacher becomes more active at this stage, explains the intended concept or subject according to the level of the class, allows the students to ask questions about the subject and helps full comprehension of the subject. At this stage, the teacher explains ordering and comparison of decimals with military ranks and distributes the students conceptual change text to demonstrate the case scientifically in mathematics.

At *the evaluation stage,* students apply their recently obtained knowledge to new situations. To achieve this, several activities such as problem solving, writing essays and linking with real life events are conducted that will allow students to experience several practices about recently learned concepts. Additionally, students are reminded with their misconceptions at the first stage and they are made aware of what they have learned. The most important property of this stage is reinforcement of recently learned concepts by different applications. At this stage, students are asked with the 6^{th} and 7^{th} questions on the last part of the worksheet for the reinforcement and transfer of the newly learned concepts to new and unfamiliar situations.

3. Results

During the application of the materials, no formal assessment was made but students made individual evaluations about the applications. The students stated that they found the materials effective, visual and interesting. At this point, students used expressions such as: *"The class was enjoyable. I liked the activities. Since we are familiar with military issues, learning becomes more permanent.", "Activities are very good, simple and understandable.", "It was nice to relate decimals with military life. I didn't know some subjects previously. Now, I learned them.", "I liked the analogy of decimals with military life. In this way, we could relate decimals with daily life."*. Generally, students claimed that instructional materials created a thought-provoking and enjoyable classroom environment. The most impressive point during implementation was relating decimals with military ranks. Therefore, the students stated that materials would be useful in teaching decimals.

4. Conclusion and Recommendation

This study develops instructional materials for students based on the four-stage models related to the subject of "decimals". Based on the results of this study, the conclusions and recommendations were presented as follows:

This model can be used in classes effectively because the number of stages is small and at each stage, instructions are explained during the implementation of materials and activities. In this context, the four-stage model is recommended for use in classrooms considering its feasibility.

Since correct perception of basic subjects of mathematics is very important, this kind of studies may be deemed necessary in mathematics instruction. Therefore, it's recommended to use the materials developed during the course in mathematics classes and to develop similar materials for other subject matters, and to investigate the effect of these materials on students' success and conceptual understanding.

References

Baki, A. (2008). *Mathematics education from theory to practice.* Ankara: Harf Educational Publications.

Baki, A., & Bell, A. (1997). *Secondary mathematics education.* Ankara: The Council of Higher Education / World Bank The Project of Improving National Education.

Baykul, Y. (2001). *Elementary mathematics education.* Ankara: Pegem Publications.

Cankoy, O. (1998). *Determining and overcoming preservice elementary teachers misconceptions in interpreting and applying decimals.* Unpublished PhD Thesis, Middle East Technical University, Graduate School of Social Sciences, Ankara.

Cankoy, O. (2000, September). *Determination of the misconceptions of pre-service teachers in interpreting and applying decimals*. Paper presented at the meeting of 4th Science Education Congress, Hacettepe University, Ankara.

Çalık, M. (2006). *Devising and implementing guide materials related to "solution chemistry" topic in grade 9 based on constructivist learning theory.* Unpublished PhD Thesis, Karadeniz Technical University, Graduate School of Natural and Applied Sciences, Trabzon.

Çepni, S. (2007). *Introduction to research and project studies*. (Extended 3rd edition), Trabzon: Celepler Press.

Ersoy, Y. (2001, May). *Educational tools in mathematics education-I: A general view and some conceptions.* Paper presented at the meeting of 2nd Mathematics Symposium Exhibition and Festival, National Library Conference and Exhibition Hall, Ankara.

Kaynak, M., Narlı, S., Köroğlı, H., Çelik, A., & Alkan, H. (2000, September). *Some recommendations on determination and removal of misconceptions of 9th, 10th and 11th graders.* Paper presented at the meeting of 4th Science Education Congress, Hacettepe University, Ankara.

Kurt, Ş., & Akdeniz, A. R. (2002, September). *Application of worksheets developed for the subject of energy in physics education.* Paper presented at the meeting of 5th National Science and Mathematics Education Congress, Middle East Technical University, Ankara.

Lawson, A. E., & Thompson, L. D. (1988). Formal reasing ability and misconception concerning genetics and natural selection. *Journal of Research in Science Teaching, 25*, 733-746.

Liebeck, P. (1984). *How children learn mathematics: A guide for parents and teachers*. England: Penguin Books.

Niaz, M. (2001). A rational reconstruction of the origin of the covalent bond and its implications for general chemistry textbooks. *International Journal of Science Education, 23(6)*, 623-644.

Saka, A. (2001). *Developing teacher guide materials for the unit of nervous and endocrin systems.* Unpublished Master's Thesis, Karadeniz Technical University, Graduate School of Natural and Applied Sciences, Trabzon.

Seyhan, G., & Gür, H. (2004). *Mistakes and misconceptions of 7th and 8th graders in the subject of decimals.* Cited from http://www.matder.org.tr/bilim/gshg.asp?ID=76 in 10.01.2008.

Steinle, V. (2004). *Changes with age in students' misconceptions of decimal numbers*. Unpublished PhD Thesis, University of Melbourne, Melbourne.

Steinle, V., & Stacey, K. (1998). *Students and decimal notation: Do they see what we see?*. Proceedings of the Thirty-Fifth Annual Conference of the Mathematical Association of Victoria, Brunswick, 415-422.

Yılmaz, Z. (2007). *Misconceptions os second degree primary school students about decimal numbers (The case of Uşak)*. Unpublished Master's Thesis, Osmangazi University, Graduate School of Natural and Applied Sciences, Eskişehir.

Appendix 1. Worksheet related to decimals

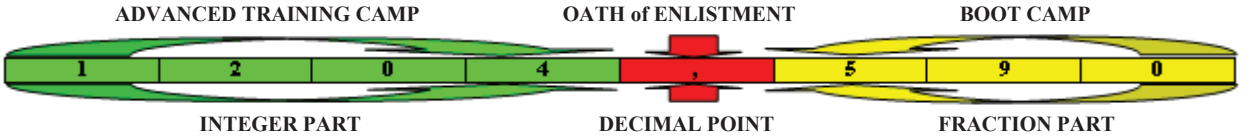
Group Elements:
Group Name :

There's a discussion between Özlem and Zeynep about which of the two is taller? Özlem is 1,55 m and Zeynep is 1,6 m long. Which one is longer in your opinion? Why?

You will find answers to this question as a result of the activities you will carry out. So, first of all try to find answers to the questions given in the activities below.

Turkish general staff declares a command to encrypt the number of commanders and soldiers at every local draft office with decimals as shown in the table below. The decimal number 1204,590 is a cipher which shows the number of commanders and troops at Trabzon center local draft office. The place of ones indicates rank of private as ***the place value***, the place of tens indicates the rank of corporal, the place of hundreds indicates the rank of captain, the place of tenths indicates the *tenth private* (**private who has 10 hours left to finish boot camp**), the place of hundredths indicates *hundredth private* (**private who has 100 hours left to finish boot camp**), the place of thousandths indicates *thousandth private* (**private who has 1000 hours left to finish boot camp**). The number in each place (digit) indicates the number of commanders or

soldiers corresponding to that place value. The fraction part of the number indicates boot camp, and the integer part shows advanced training camp and the period (decimal point) indicates oath of enlistment during the transition from boot camp to advanced training camp.



1) Put < (**smaller than**) or > (**larger than**) symbols between military ranks below.
a) Captain … Major **b)** Private … Thousandths Private **c)** Tenths Private … Corporal **d)** Major … Thousandths Private
2) Fill in the blanks with appropriate military ranks.
a) Private > …… **b)** …..... < Tenths Private **c)** Captain = …..... **d)** …..... > Hundredths Private
3) The decimal number cipher of **Akçaabat** local draft office is 1105, 234. Write military ranks **(private, corporal, …)** in the first row of the table, decimal number cipher in the second row, place names **(ones, tens, …)** in the third row.

				Oath of Enlistment			
				,			
				Decimal Point			

4) There are 1 major, 5 corporals, 4 privates, 7 hundredths privates and 2 thousandths privates at **Düzköy** local draft office. Find the decimal number cipher of this local draft office.

				Oath of Enlistment			
				,			
				Decimal Point			

5) The decimal number cipher of **Vakfıkebir** local draft office is given below. Write to the blank below how many commanders and troops are present at this local draft office.

				Oath of Enlistment			
1	0	5	4	**,**	5	8	0
				Decimal Point			

……
……
……

Try to answer the following questions using the knowledge obtained above.

6) Sedat from **Düzköy** and Adem from **Vakfıkebir** both claim that the cipher of their local draft office is bigger. Which one is bigger in your opinion? Explain why.
……
……

7) The decimal number ciphers belonging to local draft offices of **Beşikdüzü, Şalpazarı** and **Tonya** counties are given below.

County	Beşikdüzü	Şalpazarı	Tonya
Cipher	1,5	1,50	1,500

a) Write the number of soldiers from different ranks at these local draft offices beside the arrows.
1,5 ⟶ ……
1,50 ⟶ ……
1,500 ⟶ ……
b) Put < , > or = symbols between the decimals 1,5 **….** 1,50 **….** 1,500.

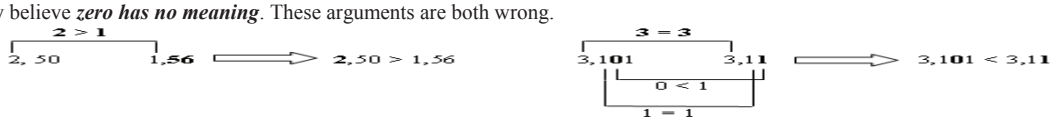
Appendix 2. Conceptual change text related to decimals

Why can't we ignore decimal point (period) which is first used by the famous Islamic-Turkish scientist **Gıyaseddin Cemşid** in mathematical operations? Explain.

Many students ignore the decimal point in decimals or perceive the decimal point as a parenthesis that separates two distinct numbers. For example, some students perceive the decimal number 5,62 as 562 or as two different number 5 and 62. *The students who ignore the decimal point when comparing decimals read a decimal number as an integer and decide which number is bigger.* For example, think that 0,21 > 0,4 because 21 > 4. But this thought is wrong.

Some students believe that ***decimals with more number of digits are either smaller or bigger***. The students who think that decimals with more number of digits are smaller argue that 1,62 < 1,3 because there are three digits in 1,62 whereas there are only two digits in 1,3. The students who think that decimals with more number of digits are bigger argue that the decimal 5,182 > (is bigger than) the decimal 6,3. But both of these arguments are wrong.

Since some of the students think that *zero makes decimals smaller* they argue that 2,50 < 1,56. Moreover some students think that 3,101= 3,11 because they believe ***zero has no meaning***. These arguments are both wrong.



Appendix 3. Analogy map related to decimals

COMPAREMENT PROPERTIES	COMPARED PROPERTIES	COMPARISON
Fraction part of the decimal	Boot camp	May be compared
Integer part of the decimal	Advanced training camp	May be compared
Decimal point separating fraction and integer parts	Oath of enlistment	May be compared
Ones digit	A soldier completing novice unit	May be compared
Tens digit	Corporal	May be compared
Hundreds digit	Captain	May be compared
Thousands digit	Major	May be compared
Tenths digit	Tenths private (A private who has 10 hours left to complete boot camp)	May be compared
Hundredths digit	Hundredths private (A private who has 100 hours left to complete boot camp)	May be compared
Thousandths digit	Thousandths private (A private who has 1000 hours left to complete boot camp)	May be compared
Digits higher than thousands digit	Ranks bigger than major	**May not be compared**
Digits smaller than thousandths digit	Thousandths private (A private who has more than 1000 hours left to complete boot camp)	**May not be compared**
Numbers at every digit of decimals	Soldiers at every military rank in an army	**May not be compared**
Number of numerals that may substitute each digit	Number of soldiers at every military rank in an army	**May not be compared**
Number of elements in the set of decimals	Number of soldiers in an army	**May not be compared**
Names of the digits of decimals	Names of the ranks in an army	**May not be compared**