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UNDERSTANDING OF ACID-BASE CONCEPT BY USING CONCEPTUAL CHANGE APPROACH

KAVRAMSAL DEĞİŞİM METODU KULLANARAK ASİT-BAZ KONUSUNUN ANLAŞILMASI

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ABSTRACT: This study explores changes of the tenth-grade students' conceptions about acids and bases by using conceptual change text oriented instruction accompanied with analogies. Since conceptual change is viewed not only as a process of replacement of old concepts but also a process of learning to relate ideas to appropriate contexts, the instruction and conceptual change text were designed to convince the students that some situations which they understand are actually analogous to other situations which they misunderstand. The results of the study showed that students in the experimental group taking conceptual change oriented instruction performed much better than the students in the control group taking traditional instruction. Thus, one could deduce that establishing analogical thinking during the course of instruction together with a conceptual change text could be a powerful tool for generating an understanding of unknown and misunderstood situations as in the case of acids and bases concept.

Keywords: conceptual change, conceptual change text, analogy, acids and bases

ÖZET: Bu çalışmanın amacı kavramsal değişim metinleri ile birlikte kullanılan benzeştirmelerin (analojiler) 10. sınıf öğrencilerinin asit ve bazlar hakkındaki bilgilerini ne şekilde etkilediğini araştırmaktadır. Kavramsal değişim yaklaşımı sadece eski yanlış bilgilerin değişmesi değil, öğrenilen bilgilerin uygun durumlarla da bağdaştırılması olduğu için öğretim ve kavramsal değişim metinleri buna göre hazırlanmış ve öğrencilerin analojik düşünme becerisinin geliştirilmesine önem verilmiştir. Çalışmanın sonuçlarından elde edilen bilgiler kavramsal değişim yaklaşımı baz alınarak deney grubunda uygulanan öğretim yönteminin, kontrol grubu öğrencilerine uygulanan geleneksel öğretim yöntemine göre öğrencilerin performasını arttırmada daha etkili olduğunu göstermektedir. Öğretim sırasında analojik düşünme becerisinin geliştirilmesine ve kavramsal değişim metni kullanmaya önem verilmesi asitler ve bazlar konusunda olduğu gibi öğrencilerin yanlış anladıkları durumları doğru anlamalarında etkili bir yöntem olabilir.

Anahtar Sözcükler: kavramsal değişim, kavramsal değişim metinleri, analoji, asitler ve bazlar

1. INTRODUCTION

One of the barriers to new learning is the misconceptions that students may have about the instructional topics. Research studies showed that students' prior experiences, background, environment, world view affect their interpretation of observations, concepts etc. As a result, students may come to the classroom with some misconceptions toward the instructional subjects to be taught. But, traditional textbooks and instructional strategies are not helpful in removing these misconceptions because simply presenting material, giving out problems and accepting answers back is not an efficient way of meaningful learning and instruction. If you understand which pre-instructional conceptions are forming students current thinking, you might be able to strategize ways for students to first question those pre-instructional conceptions before introducing new ideas. Considering the science education, there are extensive literature about the incorrect scientific understandings of students which focus on the identification of them, classification of them and evaluation of instructional strategies to change them. This process of changing the existing conception (i.e., belief, idea, or way of thinking) of students is called as conceptual change. In conceptual change, existing conceptions become a conceptual framework that students use to solve problems, explain phenomena, and function in their world. The first and most significant step in teaching for conceptual change is to make students aware of their own ideas about the topic or phenomenon under study. As students become aware of their own conceptions through presentation to others and by evaluation of those of

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their peers, they become dissatisfied with their own ideas; conceptual conflict begins to build. By recognizing the inadequacy of their conceptions, students become more open to changing them. After dissatisfaction with existing conceptions, requirements for conceptual change are that the new conception be intelligible, plausible and fruitful (Posner, Strike, Hewson, & Gertzog, 1982). There are many recent studies about the conceptual change (Liu X., 2004; Yip D., 2004; Yang et al., 2004; Abd-El-Kahlick et al., 2004).

Chemistry is one of the cornerstones of science, technology and industry. It contributes to our existence, our culture, and our quality of life. That's why, it should be taught by comprehensively and coherently. Researches showed that students have problems with some chemistry topics. Griffiths (1994) identified this topics that lead to misconceptions as chemical equilibrium, acids and bases, electrochemistry, the nature of matter, bonding, physical & chemical changes and solutions. Garnett et al. (1995) stated the list of their study as chemical equilibrium, acids and bases, electrochemistry, the particulate nature of matter and covalent bonding, molecules and intermolecular forces. There are many studies focusing on the particulate nature of matter (Novick and Nussbaum, 1978), mole concept (Novick and Mannis, 1976), chemical equilibrium (Wheeler and Kass, 1978), chemical and physical changes (Hesse and Anderson, 1992). Acid and base chemistry is one of the basic concepts in chemistry because most of the reactions are acid-base reactions. But, most students hold misconceptions about acids and bases. Cros and Maurin (1986) examined the first year undergraduate students' misconceptions about acid-base chemistry. 400 students from the two different universities were asked questions about acid and bases. Students had problems with the questions such as "what happens if you add an acid to a base?, what is the pH range for a beverage to be drinkable? In addition, most students had the idea of acids being more dangerous than bases. Banerjee (1991) developed a test to diagnose the misconceptions in chemical equilibrium including acid-base equilibrium. He determined the following misconceptions; rain water is neutral, for the same concentration of acetic acid and hydrochloric acid solution, pH of the acetic acid will be less than or equal to the pH of HCl solution in water, there is no hydrogen ion in the aqueous solution of NaOH. Ross and Munby (1991) investigated the senior high school student's understanding of acid-base concept. They reported the following findings; all acids are strong and powerful, substances that burn are acids, all acid are poisonous, fruits are basic, strong acids contain more hydrogen bonds than weak acids, all substances with sharp or strong smell are acids, acids taste bitter and peppery, soil couldn't be acidic because it is unlikely for something to grow in an acid. It was also reported that students' difficulties with ions and ionic equations prevent students from making correct links among ions, pH and other related concepts. Bradley and Mosimege (1998) studied the undergraduate student teachers misconceptions about acids and bases. They reported the following misconceptions; aqueous solutions of all salts are neutral, indicators are used to test whether an acid is strong or weak, indicators neutralize the acidic property of a solution.

One of the ways of promoting conceptual change and removing misconceptions is using conceptual change texts which are prepared to point out the students' misconceptions and their weakness of explaining or answering a problem with giving examples. Wang and Andre (1991) stated that their conceptual change text about electricity facilitated the conceptual understanding of circuits. Mikkila (2001) reported that students who studied the conceptual change text performed statistically better than the traditional text group on questions demanded construction of an adequate mental model of photosynthesis.

Analogy is another effective method to overcome misconceptions. The use of an analogical relation between the known and unknown can help the students learn new information and discard or modify misconceptions. Analogies make the new material intelligible to students by comparing it to the material that is already familiar to them. Previous studies have confirmed this in various topics of chemistry, in mathematics etc. The present study examined both, using analogy and conceptual change text to overcome the students' misconceptions about acids and bases. Results showed that teaching by analogy and conceptual change text can be an effective way of removing misconceptions and promoting conceptual change during teaching process. Stavy (1991) stated that using analogy to overcome misconceptions about "conservation of matter" can be an effective tool in teaching chemistry. Clement (1993) reported that using bridging analogies to deal with the students preconceptions in physics can play a very important role in science instruction.

During the elementary and secondary school education even in the university education of the related fields, acids-bases and their reactions occupy a considerable part of the chemistry teaching. Since they are one of the basic concepts of chemistry, student misconceptions about such topics affect their learning of this and some topics of chemistry such as solubility, chemical bonds, properties of periodic table etc. This study examined the changes in tenth-grade students' conceptions about acids and bases based on using analogy and conceptual change text and their effect on students' achievement. The findings of the study is important because it gives information about the nature of the changes that take place as a result of both methods which are simple and practical to use in teaching environments.

2. METHODOLOGY

2.1. Subjects

Subjects of the study were 47 tenth-grade students from the two classes of the same teacher in a public school at the center of Ankara. Two teaching methods used were randomly assigned to these two classes. Experimental group of 23 students received conceptual change text oriented instruction accompanied with analogies whereas control group of 24 students were instructed by traditional method.

Table 1. Taxonomy of Misconceptions in Acids and Bases Concept Test

1	The strength of an acid depends on the number of hydrogen atom and a base depends on the number of hydroxide molecule.
2	Any substance that contains H atom is an acid, OH molecule is a base.
3	Strong acids have a higher pH than weak acids.
4	At pH=0 substances are neither an acid nor a base.
5	Acids and bases show opposite properties of each other.
6	Strong acids only react with strong bases and weak acids only react with weak bases or vice versa.
7	Reactions of acids and bases always result in a neutral solution.
8	Strong acids contain more hydrogen bond than weak acids.
9	Acids are more dangerous than bases.
10	Indicators are used to provide the neutralization in acid-base reactions.
11	Only acids conduct electricity bases not
12	Soil can not be acidic because things grow in it.
13	H2O serves as solvent and can not act as an acid or base.
14	Fruits are basic.

2.2. Instruments

In this study, an acid and base misconception test (ABMT) was developed and used by the researchers considering the misconceptions reported in the literature (Ross et al., 1991; Bradley & Mosimege, 1998; Cros et al., 1986) and stated by the chemistry teachers at the interviews. Taxonomy of misconceptions measured is given in the Table 1. There were 21 multiple choice questions with one correct answer and three distractors which reflect the students' common misconceptions in acids and bases concept. Content validity of the instrument was determined by considering the experts' ideas in the Educational Faculty of METU and Chemistry Department of METU. The reliability of the test was determined as 0.81.

2.3. Procedure:

Main purpose of this study was to compare the effectiveness of conceptual change oriented instruction over traditional instruction on eliminating the tenth-grade students' misconceptions on acids and bases concept. There was one experimental group and one control group of the same teacher. Experimental group received conceptual change oriented instruction by using conceptual change text accompanied with analogies and control group received traditional instruction. Treatments were randomly assigned to two groups. An acid-base misconceptions test was given to both group as a pre-test and post-test to determine whether there would be significant difference between experimental and control group.

This study conducted in four weeks in a public high school at the center of the Ankara. A total of 47 tenth-grade students in the two chemistry classes of the same teacher were enrolled in the study.

Students in the control group instructed only with traditionally designed chemistry text i.e. tenth-grade chemistry textbook approved by Ministry of Education. During the classroom instruction, teacher used lecture and discussion methods together with problem solving in teaching acids and bases without considering students misconceptions. Major concepts, equations and definitions were written on the blackboard by the teacher and students took notes. So, the instruction was teacher-centered.

Students in the experimental group were given the conceptual change text which included the collection of students misconceptions related with acids and bases concept, questions and examples to activate these misconceptions, evidences of incorrectness of these misconceptions and correct explanations of the concepts. Lectures carried through answering the questions in the text by the students, discussing the answers and establishing analogical thinking between the real life examples and the unknown while learning new information and discarding misconceptions. For example, teacher asks to the students if there is a relationship between the number of hydrogen atoms that the acid contains and acidic strength. After taking students responses and guiding the discussions till getting the true answer go one step further and asks "Is H_3PO_4 stronger than HCl?". Then allows students to discuss again and reach the answer. In order to establish an analogical thinking with real life situations this time teacher asks "how do we measure the strength of the bulbs that we use at our homes?" and guide the discussions until students reach the fact that "If a bulb gives off a lot of light it is strong, a little light it is weak" and then helps students to establish the analogy of if an acid ionizes a lot, it is strong; ionizes a little, it is weak like in the case of bulbs. Similarly, provide students to realize that only one bulb sometimes may give more light/ may be more powerful than the two or more bulbs like in the case of the acidic strength and the number of hydrogen atoms that an acid contain i.e. HCl is stronger acid than the H_3PO_4 because it gives more hydrogen ions than H_3PO_4 when dissociates in water although it contains smaller number of hydrogen atom. Same procedure of teachers' asking the questions, guiding the students in getting true answers and establishing analogies with real life situations to eliminate the misconceptions of students by making the students dissatisfied by their own preconceptions and understand the scientifically correct explanation continues in every question in the conceptual change text. So, instruction was not teacher centered instead it was student centered.

The misconception test was applied to all groups as pretest at most one week before the instruction. After four weeks instruction of acids and bases concept, same misconception test was given again as a post test. Each question was scored as one point. Independent t-test was used to determine the difference between posttest mean scores of students who received conceptual change oriented instruction and those who received traditional instruction with respect to their achievement in misconception test.

3. RESULTS

The misconception test of the acids and bases was given to all subjects of the study as pre- and post-test. Independent-samples t-test was used to analyze the pre- and post- test data at a significance level of 0.05. The results of the pre-test showed that there was no significant mean difference between the experimental and the control group in terms of their understanding of acids and bases i.e. the experimental and the control group were equal with respect to their prior knowledge ($t= 1.92$, $p>0.05$). The results of the post-test indicated that there was a significant mean difference between the performance of students in the experimental group and the control group ($t= 5.52$, $p<0.05$). i.e. students taught by conceptual change text oriented instruction accompanied with analogies scored significantly higher than those taught by the traditional instruction. The average percent of the correct responses of the experimental group in the post-test was 57.52 % and that of the control group was 31.04 %.

4. DISCUSSION AND CONCLUSION

When teaching a topic to the students, it is important to consider the students prior knowledge about the topic. Because, students construct the new information above their prior knowledge and when this prior knowledge includes some misconceptions then the result of the instruction will be probably different than aimed by the teacher. Simply pointing out that these misconceptions are wrong is not helpful to eliminate them. That's why, teachers should be sensitive about the students' probable misconceptions about the instructional topics when designing their instruction and selecting instructional materials. In this study, classroom instruction and materials about the acids and bases concept planned with this aim. The four weeks intervention of conceptual change text oriented instruction accompanied with analogies caused a significantly better acquisition of the concepts and elimination of misconceptions than the traditional instruction. Because, conceptual change text helped the students revise their prior knowledge, realize the common misconceptions and correct them in acids and bases concept and enhancing of analogical thinking during the instruction served as a bridge between the real life examples/everyday phenomena around us and misunderstood concepts providing students a better understanding of confusing and difficult concepts. Thus, the conceptual change oriented instruction resulted in better conceptual understanding by the students as can be seen from the results. Another implication of the study is that traditional instruction was not as effective as the conceptual change instruction in eliminating misconceptions about the instructional topics as indicated in previous studies (Hynd et al., 1994; Andre and Chambers, 1997; Weaver, 1998; Mikkila, 2001). Because, by the traditional instruction knowledge is simply transmitted as a unidirectional stream of data flowing from the teachers to the students. That's why, teachers should be informed about the application of conceptual change strategies in classrooms and conceptual change instruction should be alternative to the traditional instruction. Moreover, researchers and the curriculum developers should focus more on the students' prior knowledge and misconceptions since it is well recognized that most students are unable to effectively learn all of the material in their lectures.

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