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THE EFFECT OF CONCEPTUAL CHANGE TEXTS ORIENTED INSTRUCTION ON STUDENTS' UNDERSTANDING OF THE SOLUBILITY EQUILIBRIUM CONCEPT

KAVRAMSAL DEĞİŞİM METİNLERİNE DAYALI ÖĞRETİMİN ÖĞRENCİLERİN ÇÖZÜNÜRLÜK DENGESİ KONUSUNU ANLAMASINA ETKİSİ

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ABSTRACT: The present study aimed to investigate the effect of conceptual change texts oriented instruction on 10th grade students' understanding of solubility equilibrium concept. The misconceptions related to solubility equilibrium concept were obtained through interviews with high school chemistry teachers and related literature. The data were obtained from 58 students participated in instruction based on conceptual change approach and 67 students participated in instruction based on traditional methods. The results of the study showed that instruction based on conceptual change approach where conceptual change texts were used, was better than the instruction based on traditional methods on remediation of misconceptions and promoting students' understanding of solubility equilibrium concept.

Keywords: conceptual change approach, conceptual change texts, solubility equilibrium

ÖZET: Bu çalışma, kavramsal değişim metinlerine dayalı öğretimin 10. sınıf öğrencilerinin çözünürlük dengesi konusunu anlamasına etkisini incelemeyi amaçlamıştır. Çözünürlük dengesi ile ilgili kavram yanılgıları lise kimya öğretmenleri ile yapılan mülakatlardan ve ilgili literatürden elde edilmiştir. Çalışmanın verisi, kavramsal değişim yaklaşımını baz alan öğretim yöntemine katılan 58 öğrenci ve geleneksel metotları baz alan öğretim yöntemine katılan 67 öğrenciden elde edilmiştir. Çalışma sonucunda elde edilen bilgiler kavramsal değişim metinlerinin kulanıldığı kavramsal değişim yaklaşımına dayanan öğretim yönteminin geleneksel öğretim yöntemlerine göre öğrencilerin kavram yanılgılarını gidermede ve çözünürlük dengesi konusunu öğrencilerin anlamasında daha etkili olduğunu göstermiştir.

Anahtar Sözcükler: kavramsal değişim yaklaşımı, kavramsal değişim metinleri, çözünürlük dengesi

1. INTRODUCTION

Students develop diversity of views about objects and events around them before coming to school. Some of these views students bring to chemistry instruction are inconsistent with that of scientific community. These different or inconsistent conceptions have been called misconceptions. Misconceptions are highly resistant to change, persistent and difficult to extinguish and can not easily be removed by traditional instruction (Sungur, Tekkaya & Geban, 2001; Wandersee, Mintzes & Novak, 1994). In other words, simply presenting the content without considering the students' misconceptions is not an effective way of teaching science since learning science in meaningful way involves realizing, recognizing or replacing existing conceptions to accommodate new ideas (Smith, Blakeslee & Anderson, 1993). If students' ideas differ from the definition accepted by scientists, students will fail to form appropriate links and associations between new knowledge and preexisting knowledge. Therefore, identification of students' misconceptions and finding ways to remediate these misconceptions to promote meaningful learning is very important; since, if students' misconceptions are known, chemistry instruction can be planned in a way that students' incorrect scientific understandings will first be discussed before introducing new ideas.

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To promote meaningful learning various instructional methods that are based on constructivist theory of learning have been used to identify and remediate misconceptions students have. One of such methods involves the use of conceptual change approach in which students' preexisting conceptions are restructured or changed. In other words, conceptual change occurs when learner changes misconceptions with that of scientifically accepted ones and changing misconceptions requires modifying or restructuring existing schemata. Several models are proposed for conceptual change that addresses how misconceptions can be remediated. The most well known conceptual change model was proposed by Posner and his colleagues (1982). They claim that four conditions of accommodation needed to be present for conceptual change to occur. First, there must be dissatisfaction with existing conceptions. Second, a new conception must be intelligible. Third, a new conception must appear plausible. Finally, a new concept should suggest the possibility of a fruitful research program. A considerable number of studies have been done in conceptual change in science education presented the effectiveness of instructions based on conceptual change approach on understanding of science concepts (Chiu, Chou & Liu, 2002; Hynd et al., 1994; Mikkila-Erdmann, 2001).

Several strategies based on conceptual change approach were developed to overcome misconceptions students have. One of these strategies involves the use of conceptual change texts (CCT). According to Roth (1985), in conceptual change texts, common misconceptions of students are first identified. Then, a situation which was prepared to activate students' common misconceptions is presented to elicit prediction about the phenomena. Next, students' misconceptions are challenged by introducing common misconceptions followed by evidence that they are wrong. Finally, the correct scientific explanation is presented. In other words conceptual change text presents alternative conceptions, refutes it by explaining why it is not scientifically accepted and provides an explanation of the scientific conception to help remediation of misconceptions. The effectiveness of CCTs on remediation of misconceptions and enhancing understanding of science concepts were presented by many researchers (Cakir, Yuruk & Geban, 2001; Chambers & Andre, 1997; Hynd, Alvermann & Qian, 1997; Mikkila-Erdmann, 2001; Sungur, Tekkaya & Geban, 2001; Tekkaya, 2003; Wang & Andre, 1991). Moreover, Guzzetti et al. (1993) meta-analyzed the literature on conceptual change texts and they concluded that conceptual change texts facilitate learning of science concepts.

Several researchers indicated that chemistry is considered as an abstract and difficult subject to learn by many students (Nieswandt, 2001; Pınarbaşı & Canpolat, 2003). The major reason of finding chemistry concepts difficult is the lack of understanding of chemistry concepts. Since the goal of chemistry education is to help students develop proper understanding of chemistry concepts, it is therefore important in chemistry instruction to find ways that will promote meaningful learning. Therefore, it is necessary to conduct research on misconceptions students have related to chemistry concepts. However, the works in which the misconceptions of students in chemistry are investigated, are limited to some topics such as mole concept (Case & Fraser, 1999; Staver & Lumpe, 1995), matter concept (Krnel, Glazer & Watson, 2003; Nakhleh, 1992), bonding (Coll & Treagust, 2003; Nicoll, 2001; Tan & Treagust, 1999), solution chemistry (Ebenezer & Gaskell, 1995; Smith & Metz, 1996), chemical equilibrium (Camacho & Good, 1989; Chiu, Chou & Liu, 2002; Gussarsky & Gorodetsky, 1990), electrochemistry (Sanger & Greenbowe, 1997; 1999) and acid-base chemistry (Cakir, Uzuntiryaki & Geban, 2002). Although students of secondary school are often confused by concept of solubility equilibrium (Raviolo & Alexander, 2001), studies that investigate the concept of solubility equilibrium are not many. However, in high school chemistry curricula solubility equilibrium occupies a central role. It is a difficult concept since some topics such as solubility, physical and chemical equilibrium, Le Chatelier's principles, solution chemistry and chemical equations should be first learned before solubility equilibrium is taught. In addition, solubility equilibrium is fundamental to students' understanding of other chemical topics. Therefore, it is important to find out students' earlier conception in order to plan future activities while teaching solubility equilibrium concept.

The literature review presented that misconception hinder learning; therefore, it is very crucial to identify misconceptions and find ways to remediate these misconceptions. This shows the necessity to conduct a research to improve chemistry learning. For this reason the present study was designed to investigate the effectiveness of conceptual change texts oriented instruction on tenth grade students' understanding of solubility equilibrium concept.

2. METHOD

2.1. Subject

Subjects of the study were 125 tenth grade students from the four science classes of a public high school at Ankara. The classes were randomly assigned as control group and experimental group since because of strict school schedule it is difficult to arrange classes by selecting students randomly. The data analyzed in this research study were taken from 58 students participated in instruction based on conceptual change approach where conceptual change texts (CCT) were used (experimental group) and 67 students participated in instruction based on traditional methods (control group). The sample was composed of 51 male and 74 female students.

2.2. Instruments

Random assignment of individuals to control and experimental groups were not possible; therefore, before the treatment solution concept test (SCT) was administered to both experimental and control groups in order to control preexisting difference between groups. After the treatment solubility equilibrium concept test (SECT) was administered to all groups as a post test.

Solution Concept Test (SCT)

The test was developed by researcher. The test was administered as a pre test to both experimental and control group students in order to determine whether there was any difference between two groups at the beginning of the treatment. There were 20 multiple choice items related to solution and solubility concepts in the test. Content validity of the instrument was determined by considering the ideas of experts in chemistry education and chemistry and several high school chemistry teachers. The reliability coefficient calculated for internal consistency was 0.79.

Solubility Equilibrium Concept Test (SECT)

The test was developed by the researcher considering misconceptions that students have related to solubility equilibrium concept. Misconceptions students have with respect to solubility equilibrium concept (see Table 2.1), were obtained from the literature related to solubility equilibrium and interviews with chemistry teachers. The test was composed of 30 multiple choice items where distracters of each item were arranged in a way that they reflect students' misconceptions. Content validity of the instrument was determined by considering the ideas of experts in chemistry education and chemistry and several high school chemistry teachers. The reliability coefficient calculated for internal consistency was 0.81.

Table 2.1. Taxonomy of Misconception Related to Solubility Equilibrium.

1. There is no precipitation and dissolution at equilibrium.
2. Dissolution stops at equilibrium.
3. Concentrations of the ions produced are equal to the concentration of the salt at equilibrium.
4. Mass can be used instead of concentration in K_{sp} calculations.
5. Coefficients in solubility equilibrium equation have no other meaning then equating the solubility reaction.
6. Ksp can change at a given temperature.
7. Ion product (Qi) can be used interchangeably with K_{sp}.
8. While writing K_{sp} equations, compounds in solid form should be included.
9. The rate of dissolving increases with time from mixing the solid with solvent until equilibrium establishes.
10. There is no relation between K_{sp} and solubility.
11. The value of K_{sp} changes with the amount of solid or ions added at a given temperature.
12. The value of K_{sp} always decreases as temperature decreases.
13. Temperature has no affect on solubility.
14. At equilibrium, addition of salt affects the equilibrium.
15. Concentrations of ions will remain constant although common ion is added at equilibrium.
16. Solubility of sparingly soluble salts is affected by change made in pressure and volume.
17. In all situations one can compare solubility of salts at equilibrium by just looking at K_{sp} values.
18. If system is at equilibrium no other solute that doesn't contain common ion can dissolve.
19. There was no precipitation reaction before the system reaches equilibrium.
20. Large K_{sp} implies very fest dissolution.

Note. K_{sp}: solubility product constant

2.3. Procedure

Several high school chemistry teachers were interviewed in order to determine students' misconceptions in solubility equilibrium concept before the study. In interviews, participating teachers were asked whether they have observed any misconception related to solubility equilibrium and have also handed a copy of misconceptions obtained from literature review and were asked to indicate whether their students have such misconceptions. The duration of interviews were ranged from 50 to 70 minutes. The researcher then developed the solution concept test (SCT) which was used as a pre test. Researcher did not used solubility equilibrium concept test (SECT) as a pre test since students were unfamiliar with such concepts; therefore, if it was used results obtained would probably be effected much by chance factor. Therefore, SCT was used since students have already been instructed on solution concepts. By the help of misconceptions obtained, SECT was developed. In addition, the researcher developed the lesson plans and conceptual change texts (CCT) before the study. While developing CCTs, Roth's (1985) procedures were used. In these texts analogies, examples and graphic organizers were used to make content more concrete and easy to understand. Then two chemistry teachers received three hour training where they were informed of constructivism, conceptual change approach and how CCTs would be used. Moreover, teachers were trained on standard test administration procedures. Each teacher had one control and one experimental classroom. Control group students received materials and assignments based on traditional methods of teaching. The experimental group on the other hand received instruction and materials based on conceptual change approach. Both experimental and control groups were instructed on the solubility equilibrium concept in coherence with the chemistry curriculum. Students in control group were instructed by traditional designed chemistry instruction in which teacher centered instructional methods were used. In other words, while instructing, teachers generally used lecturing and questioning methods without considering students' misconceptions. Major concepts, equations, and definitions were given and students were taking notes while listening to the lectures. In other words, students in traditional methods were in classes to listen and learn. Students in experimental group were instructed by conceptual change approach in which CCTs were used. In experimental group, students were given an opportunity to ask questions, discuss the topic individually and with their friends, and present their understandings. In addition, students had the opportunity to realize that some of their preconceptions are inconsistent with that of scientific explanations by the help of conflicting conditions. Conflicting conditions were presented related to solubility equilibrium concept by teachers in order to activate students' preconceptions. For example, students were presented with condition in which $Na_2SO_3(s)$ dissolves in water and the solution reaches the state of equilibrium. Then, students were asked to explain whether any precipitation occurs before the solution reaches the state of equilibrium. Moreover, they were asked to predict whether it is possible to calculate Ksp for unsaturated solutions and whether Ksp always decreases as the temperature decreases. It was aimed students to realize that something is wrong with their preconceptions. The conflicting situations presented above were presented to activate students' misconceptions such as "there was no precipitation reaction before system reaches the state of equilibrium, ion product can be used interchangeably with Ksp and Ksp always decreases as temperature decreases". This is in agreement with Posner et al's (1982) first condition for conceptual change. They indicated that in order to achieve conceptual change first of all there must be dissatisfaction with existing conception since students do not easily accept new concepts. While instruction, teachers explained why misconceptions that students hold are wrong. Moreover, they explained the scientifically correct answer by analogies, demonstrations and providing daily life examples. For example, to explain that when equilibrium is reached the processes of dissolution and decomposition do not finish, teachers used the analogy of an escalator (moving staircases). By the help of this analogy, students would probably realize that at equilibrium the rate of decomposition is equal to rate of dissolution. In this stem teacher tried to accomplish Posner et al.'s (1982) conditions of intelligibility and plausibility. However, teachers were reminded by the researcher of the importance of proper usage of analogies in order not to cause any misconception. In addition, some daily life examples were given to students such as formation of stalactites and stalagmites to help students realize that chemistry is important for explaining environment around us. They also saw the usage of new concept in different situations. Therefore, Posner et al.'s (1982) last condition is also achieved. At the end of treatment both groups received SECT which was administered by the teachers to their classes in 40 minutes time in their regular classes.

Before students receive the treatment, the researcher and a faculty ensured that desired data can be obtained by the help of instrument prepared. In addition, the researcher observed the treatment and the administration of tests in order to decide whether treatment was done as defined in the study. Therefore, while conducting the study the researcher observed several lessons and completed the observation checklist prepared by the researcher. The observations indicated that the treatment was done as defined in the study.

3. RESULTS

The results presented that there was no significant difference between control group and experimental group in terms of students' understanding of solution concept, t (123) = 0.583, $p > 0.05$ at the beginning of the treatment. The experimental group (EG) students and control group (CG) students pre test mean scores were, $\overline{x}$ EG = 12.88, $\overline{x}$ CG = 12.63, respectively. A significant result was obtained from t-test analysis, t (123) = 11.509, $p < 0.05$ after the treatment. The t-test results showed that there was a significant difference between the post test mean scores of students taught by traditionally designed instruction and those taught by instruction based on conceptual change approach with respect to understanding solubility equilibrium concept. The experimental group students scored significantly higher than control group students. The experimental group and control group students' post test mean scores were $\overline{x}$ EG = 17.78, $\overline{x}$ CG = 12.39, respectively.

4. DISCUSSION AND CONCLUSION

The main purpose of the present study was to investigate the effectiveness of conceptual change texts oriented instruction on 10th grade students' understanding of the solubility equilibrium concept. In this study SCT was administered before the study in order to determine students' prior knowledge since students' prior knowledge is important in the integration and construction of new knowledge in to their existing cognitive structures. It was observed that there was no significant difference between two groups regarding their chemistry knowledge before the treatment. Before the treatment, interviews were conducted with chemistry teachers in order to identify students' misconceptions. The interview results indicated that many students have misconceptions relevant to solubility equilibrium. Most of the interviewers indicated that their students have difficulty in understanding the dynamic nature of the solubility equilibrium, solving Ksp problems and understanding and interpreting graphs related to solubility equilibrium concept. In addition, the researcher and the participants discussed the reasons of observing these difficulties and presented the taxonomy of misconceptions related to solubility equilibrium (see Table 2.1). During the treatment experimental group students received instruction based on conceptual change approach where CCTs were used, while students in the control group received instruction based on traditional methods. The results revealed that three weeks instruction of conceptual change texts oriented instruction caused a significantly better acquisition of solubility equilibrium concepts and elimination of misconceptions than the traditional instruction. This difference may result from the fact that conceptual change texts helped students to realize that some of their prior knowledge is inconsistent with that of scientific view and helped students to remediate their misconceptions and therefore form appropriate links and associations between concepts which enhance meaningful learning. Results also revealed that it is not easy to remediate or eliminate misconceptions by traditional instruction since in traditional instruction there was no emphasis on students' misconceptions but just introducing the important concepts by lecturing, problem solving and strictly following the textbooks which makes the students passive learners.

Distracters of each item in the post test were designed in a way that they reflect misconceptions students have related to solubility equilibrium. Therefore, proportion of responses given to distracters showed how effective each method was on remediation of misconceptions. It is observed that after the treatment some of the experimental group students hold some of the misconceptions presented in Table 2.1 since there were items in which the experimental group students' responses were loaded on one incorrect alternative. In other words, some of the experimental group students were still holding some of the misconceptions such as, "there is no relationship between Ksp and solubility, the temperature has no effect on solubility and the concentration of ions will remain constant although common ion is added" after the treatment. One of the reasons of obtaining such result could be the length of the study since the treatment was implemented just for three weeks. Although it is observed that after the treatment experimental group students could also hold some of the solubility equilibrium misconceptions, results of the study indicated that the proportion of students that have these misconceptions in experimental group is low compared to that of control group students. Moreover, proportion of correct responces given to these items by experimental group students was higher than the proportion of correct responses given by control group students. Therefore, it can be concluded that instruction based on conceptual change approach was more effective on remediation of misconceptions than the instruction based on traditional methods.

Literature review indicated that most of the high school students have misconceptions in various chemistry concepts including solubility equilibrium. However, there are not many studies related to solubility equilibrium concept. Therefore, the taxonomy of misconceptions presented in this study gains importance. The results of this study support the previous studies in chemistry literature which indicated that students have misconception on variety of chemistry concepts. Therefore, teachers should be aware of students' prior knowledge and misconceptions since students construct knowledge by the help of already existing conceptions. Moreover, teachers should understand the importance of conceptual change texts so that they can plan future activities in a way that instruction promotes meaningful learning. In addition, they should realize that it is difficult to remediate misconceptions by traditional methods since it is not enough to simply present the important concepts because research studies presented that misconceptions are highly resistant to change. Therefore, teachers should be encouraged to use conceptual change texts. Researchers and curriculum developers should focus more on the students' prior knowledge, misconceptions and finding ways to remediate misconceptions since it is well recognized that misconceptions prevents formation of appropriate associations between concepts and therefore hinder meaningful learning.

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