EFFECTIVENESS OF CASE-BASED LEARNING INSTRUCTION ON STUDENTS' UNDERSTANDING OF SOLUBILITY EQUILIBRIUM CONCEPTS[*]

ÖRNEK OLAY TEMELLİ ÖĞRENME YÖNTEMİNİN ÖĞRENCİLERİN ÇÖZÜNÜRLÜK DENGESİ İLE İLGİLİ KAVRAMLARI ANLAMALARINA ETKİSİ

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ABSTRACT: This study was conducted to investigate the effectiveness of learning activities based on case-based learning over traditionally designed chemistry instruction on eleventh grade students' understanding of solubility equilibrium. The subjects of this study consisted of 63 eleventh grade students from two intact classes of an urban high school instructed with same chemistry teacher. Each teaching method was randomly assigned as control and experimental group. The experimental group received case-based learning, in which real life cases were discussed via small group discussions; the control group received traditional instruction in which lecturing and discussion was carried out. The results showed that case-based learning instruction produced significantly greater achievement in understanding of solubility equilibrium concepts in comparison with traditional instruction. Also, the results revealed that students had misconceptions related to chemical equilibrium. According to the results of this study, case-based learning is effective for elimination of misconceptions and the enhancement of students' understanding.

Keywords: case based learning, misconceptions, solubility equilibrium.

ÖZET Bu çalışma, örnek olay temelli öğrenme yönteminin onbirinci sınıf lise öğrencilerinin çözünürlük dengesi ile ilgili kavramları anlamalarına etkisinin geleneksel yöntem ile karşılaştırmak için gerçekleştirilmiştir. Bu çalışmanın örneklemini aynı kimya öğretmenin iki ayrı onbirinci sınıfındaki 63 öğrenci katılmıştır. Sınıflar kontrol ve deney grubu olarak rastgele seçilmiştir. Deney grubu öğrencileri; belirli durumların, genellikle günlük hayat örnek olaylarının tartışıldığı örnek olay temelli öğrenme yöntemi ile öğrenim görmüşlerdir. Buna karşılık, kontrol grubu öğrencileri geleneksel yöntemle öğrenim görmüşlerdir. Sonuçlar örnek olay temelli öğrenme yönteminin geleneksel yönteme göre çözünürlük dengesinin anlaşılmasında daha etkili olduğunu göstermiştir. Elde edilen sonuçlar öğrencilerin çözünürlük dengesiyle ilgili kavram yanılgılarının olduğunu açığa çıkarmıştır. Bu çalışmanın sonuçlarına göre, örnek olay temelli öğrenme, kavram yanılgılarının giderilmesinde ve öğrencilerin anlamalarını pekiştirmek açısından geleneksel yönteme göre daha etkindir.

Anahtar sözcükler: örnek olay temelli öğrenme, kavram yanılgıları, çözünürlük dengesi.

1. INTRODUCTION

Students come to classes with their attitudes, abilities and experiences; and these properties influence students' learning in instruction. According to Ausubel (1968) the most important indication of learning is what the learner already knows since an image or an example directs the learner to relevant prior experience or learning and also points forward to new material. In line with this view Shapiro (2004) and Dochy, Segers, and Buehl (1999) stressed the importance of prior knowledge in learning. Thus, students shape their own meaning accordingly.

Errors are characteristics of initial phases of learning because students' existence knowledge is insufficient and supports only partial understanding. However, many researchers revealed that students' views about an image or an example are not match with scientific views. Even after formal instruction, students learn concepts different from scientific consensus, and these wrong ideas are called "misconceptions". Misconceptions mean the difference between learner's understanding and scientifically accepted understanding of the concept. However, they do not mean the lack of knowledge, factual errors or incorrect definitions. They are the demonstration of the constructed explanations of students in response to their prior knowledge and experience. They are resistant to change with traditional instruction because of instruction's inefficiency on constructing consistent relations among concepts and developing

conceptual frameworks. Thus, misconceptions hinder students' learning, and as Ausubel (1968) states the formation of relations between ideas, concepts and information and also the linkage between concepts are interrupted. Thus, students could not establish meaningful learning.

In chemistry instruction, many researchers mentioned that students could not establish meaningful learning because of ignoring the presence of misconceptions. Chemistry is considered as abstract and difficult for students (Nieswandt, 2001; Chittleborough, Treagust & Mocerino, 2002). To get rid of this, students must actively seek out knowledge, acquire it, and construct it to obtain a deeper understanding of the chemistry concepts. Therefore, researches concerned on students' misconceptions are very important. The chemistry topics investigated on students' misconceptions are mole concept (Duncan & Johanstone, 1973), entropy (Frazer, 1980), chemical equilibrium (Camacho & Good, 1989; Gussarsky & Gorodetsky, 1990; Chiu, Chou & Liu, 2002), covalent bonding (Peterson & Treauget, 1989), electrochemistry (Garnett & Treaguest, 1992a; 1992b), acid-base chemistry (Ross & Munby, 1991), solubility equilibrium (Önder & Geban 2006).

Solubility equilibrium is a complex topic since it integrates solubility, molarity, physical, chemical equilibrium and Le Chatelier's principles concepts. Also, it interacts with biology concept such as osmotic pressure and osmosis. Thus, instruction eliminating students' misconceptions should be found out. While considering the teaching method students' prior conceptions, development of meaningful learning should be taken into account. Constructivist learning theorists emphasized the role of mind in learning, meaningfulness of learning thing, and active involvement in learning process (Bruner, 1966). Lockwood (1992) defined that learner should be encouraged for constructing their own learning by using many forms of activities and so they will be willing to respond instruction. Thus, the role of learner is to solve nonroutine problems related to the subject area.

According to constructivist approach multiple perspectives of learning environments are required. Learning environments should include 'reality, knowledge construction and context-rich, experience based activities' (Jonassen, 1992, p.137). Thus, real life examples and case based learning environments facilitate constructivist learning (Jonassen, 1994). Case based learning instruction promotes students' active participation and constructs their own learning in class. In fact, cases are stories with a message, these stories are firstly used in the law, business, and medical schools and afterwards they are used in undergraduate classrooms. Students analyze and consider solutions of cases. Students' higher order thinking skills and teamwork abilities are improved (Herreid, 1994). Teachers could make use of cases through questioning, discussion in class by starting lesson with a open-ended question having definite and simple answer; this could be trouble but students could answer that question and then discussion is proceed and a product should be produced (Herreid, 1994). While conducting case- based instruction with small group activity; students make groups of students and they examined and interpreted that case together and then whether they solve the case related questions by theirselves (Herreid, 1994).

Cases benefit teacher for taking attention of students because students like stories, but teacher should be careful about losing the control of purpose of transforming desired purpose of the case. Cases could be used in many forms so the class environment will be interactive by using this instruction in chemistry subject, students' chemistry achievement will be enhanced. Inquiry can be done using case-based learning and with this using real life scenarios and stories enhance students learning through the impact of active participation in instruction (Fasko, 2001). In the classroom setting, teacher should create an environment fostering students' inquiry skills. Instructors can do this by generating cases or counter-examples to learners for producing hypotheses, predictions, and revealing their misconceptions and ideas (Smith & Murphy, 1998).

To sum up, misconceptions are important obstacle affecting students' learning in chemistry topics. Due to its difficulty, multiply integrated and abstract nature, solubility equilibrium is analyzed by case-based learning instruction for eliminating students' misconceptions and developing meaningful learning. Case- based learning instruction is interactive and it includes students' active participation in class.

The purpose of this study is to investigate the effectiveness of learning activities based on case-based learning over traditionally designed chemistry instruction on eleventh grade students' understanding of solubility equilibrium. In addition to this, the present study examined the difference between girls and boys with respect to understanding of solubility equilibrium concept. The other purpose of the study is that to find out the effect of interaction between gender difference and treatment on

students' understanding of solubility equilibrium concept. Also, this study was conducted in order to determine the students' misconceptions related to chemical equilibrium.

2. METHOD

2.1. Sample

The sample of this study consisted of 63 eleventh grade students from two intact classes of an urban high school which were instructed by the same teacher. These two classes were assigned as control group and experimental group randomly. Experimental group students were instructed with case-based learning instruction while control group was instructed with traditional instruction. The number of students in experimental group was 28 and the number of students in control group was 35. The mean age of the students was 16.

2.2. Instrumentation

All of the students were administered by three instruments; 1) Solution Concepts Test 2) Solubility Equilibrium Concepts Test 3) Open-Ended Solubility Equilibrium Test.

2.2.1 Solution concepts test (SCT). This instrument was developed by Önder and Geban (2006) for measuring students' understanding on solution and solubility concept. It includes 20 multiple choice items and most of which requires students to reflect misconceptions and others requires computations. The reliability coefficient was found to be .72. This instrument was administered to both experimental and control groups as a pre-test to measure their background knowledge with respect to understanding of solubility concepts.

2.2.2 Solubility equilibrium concepts test (SECT). This instrument was developed by Önder and Geban (2006) for measuring students' understanding on solubility equilibrium considering misconceptions. It includes 30 multiple choice items and each item rated as one point. The reliability of the instrument was found 0.66. This instrument was administered to both experimental and control groups as a post-test after the treatment. One item from this instrument is given below.

At 25°C $CuCO_{3(aq)}$ is equilibrium with its solid. At the same temperature if some amount of X salt, which is not forming compound with Cu^{+2} ve CO_3^{-2} ions, added to the solution, what happened?

A. X salt precipitates without dissolution.

B. The solubility of $CuCO_3$ increases.

C. The solubility of $CuCO_3$ decreases.

D. K_{SP} of the $CuCO_3$ solution does not change.

2.2.3 Open-ended solubility equilibrium concept test (OSECT). This instrument was developed by researchers for measuring students' understanding on solubility equilibrium concept considering misconceptions. It includes 13 open-ended questions, which requires students to understand, predict and evaluate given situations. The test measures misconceptions, difficulties and essential concepts to be learned. The content of the test was determined from examining related literature such as textbooks, journals and books (Ebbing, 2001, Brecevic & Kralj, 2007, Romero, Eriksen & Haworth, 2004). This test assessed students' knowledge related to solubility equilibrium by solving nonroutine questions including real life inferences and so they are able to understand the concepts which are root of solubility equilibrium and also they are able to interpret chemical equilibrium which is related to solubility equilibrium subject. The content validity of the test was provided by science educators, science teachers, prospective science teachers for examining the appropriateness of the test items and objectives. Also, they examined the test for grade level and understandability for students. The reliability of the instrument was found .87. One example from this instrument is given below. *AgNO₃ and KI solutions were mixed, how can we determine whether the precipitation formed or not? To determine this which kind of information we need?*

2.3. Treatment

This study lasted six weeks. In this study total 63 students involved and they were taught by the same teacher of two classes through the semester. Two classes were observed for controlling teacher

effects, and treatment verification. One of the classes assigned as a control and the other as an experimental group randomly. Control group was instructed by traditional instruction while experimental group was treated by case- base learning instruction. Students were treated in solubility equilibrium subject of chemistry curriculum. The intervention took six weeks.

Students in control group were instructed by lecturing method and discussion in that students were passive listeners and teacher's role was to transmit the facts and concepts to the students. Also, the students read related topic before lesson, and during lesson teacher emphasized topics in textbooks if students had questions teacher answered them and students listened and took notes. After the lesson worksheets were given to students and students responded them. Questions in worksheets were direct questions related to topic. However, students' misconceptions and previous knowledge were not considered by teacher while teaching.

The experimental group was treated with case-based learning instruction. Herreid (1998) classified the case study methods in four different ways: individual assignment, lecture, discussion and small group activities. The definition of the case is the same in all of the forms; however, the students' and the teacher roles' are chancing in each case form. In this study, case based learning instruction is employed with small group format in which students work in the small group and teacher works as a facilitator. Thus, students could learn more from each other. Also, the learning of solubility equilibrium topic is difficult since it is integrated to other concepts such as dissolution, stoichiometry, chemical equations, ionic compounds, chemical equilibrium characteristics, solubility, common ion effects and Le Chatelier's principle. Thus, small group format is suitable for promoting students' learning.

In this study six cases related to real life scenarios were used. Each case followed questions which were integrated to related issue in case and misconceptions. Cases firstly discussed in small group and then students discussed with class. Then, they came to conclusion about each case.

Students were introduced with a case of Hard Water.

The owners of the washing machine complained about the damage on the resistance of their machine after taking it a year. They said that when they took that machine, initially there is no problem but after some time machine worked loudly and their clothes couldn't clean as the first time even high temperatures and at the end it doesn't work anymore. The general manager of the factory decided to establish research team for solving this problem with lower budget.

The general manager decided that this class will be research team of his factory. For this, you are going to work with five or four in small group. After that all group responses will be discussed in class.

Background

Water used in machines is hard in that it contains mainly Ca^{2+} and Mg^{2+} ions and these cause the damage of the machine. While water contacts with rocks and sediments in the environment, it dissolves them and water becomes hard. It was proposed that when water contains only calcium sulfate, sodium carbonate added to that water, thus the damage became lesser than previous.

This case was given to students one week prior to the lesson. After students analyze cases before class, possible solutions were found such as *precipitation on resistance increases due to the shaking speed of the solution formed in washing machine, to decrease precipitate foreign substances could be added to water in the washing machine.* Then, in class, case was presented to the class and small group discussion (in each group 5 or 4 students) was proceeded to analyze it. Firstly, each group discussed the case questions. The first question is

If sodium sulphate instead of sodium carbonate added to the calcium sulphate containing water, what happened, does it work? Give your reasoning.

When teacher observe class during solving this question, she take attention of some responses. Some of the students in group stated that '*yes, because both added salts are soluble in water',* and other group stated that '*no, because when sodium sulphate added to solution, it dissolves in water completely but sulphate started to make calcium sulphate compound again'.* After this question solved students pass through other question. This question is: *Why hard water causes damage in machine?* Again students in group discussed this question by '*hard water contains ions and these made compound with detergent and thus machine damaged.'* The other group stated that '*hard water was harmful because its ions made precipitate when they are shaking in washing machine'*

After all of the questions were discussed in group, all class started to discuss the case. While doing these, follow up questions were directed toward students for enhancing consideration and understanding of the important concepts. For example, "what is the reason of precipitation?", "how the solubility is change, when common ions or other than common ions added to the solution? At the end of the all class discussion, students revealed the important concepts of the case and summarized it. Thus, students solved the questions about the case and comprehended the common ion effect on solubility.

Thus, cases directed students toward a conclusion or provided resources and context to discuss and debate issues dynamically. Researcher with teacher prepared an outline of concepts and subconcepts to be discussed through the case. Also teacher was trained about case- based learning instruction by researcher. Cases related to topic were prepared by researcher, after that, they were examined by teacher and experts about appropriateness of the topic and students' cognitive level.

3. FINDINGS

Independent sample t test analysis results showed that at the beginning of the treatment there was no statistically significant difference between mean scores of the experimental and the control group students with respect to their understanding of solution (t= 1.30, df=60; p>0.05).

3.1. Contribution of treatment to understanding of solubility equilibrium concepts

3.1.1. Using Solubility Equilibrium Concepts Test as a post test

After the treatment, Two-Way Analysis of Covariance (ANCOVA) was carried out, with treatment and gender differences as the independent variables, students' SCT scores as a covariate and students' performance related to SECT as the dependent variable. Descriptive measures of Solubility Concept Test are presented in Table 1.

Table 1: Descriptive Measures of Solubility Concept Test

	Pretest			Posttest	
	n	M	SD	M	SD
Experimental group	27	8,9	2,9	23,6	3,81
Control group	35	9,8	2,4	20,9	3,73

Table 2 demonstrated the ANCOVA results of SECT. As shown in Table 2, statistical analysis indicated that there was a statistically significant difference between the experimental and control groups' mean scores on the SECT scores in favour of the experimental group (F(1,57)=22.007, p<0.05). The experimental group students scored significantly higher than control group students, X_{EG}= 24.05 and X_{CG}= 20.51, respectively. The students in the experimental group who were engaged in case-based learning instruction demonstrated better performance compared to the control group students who were engaged in traditional instruction. Also, as shown in Table 2, the results demonstrated that the prior knowledge made a statistically significant contribution to understanding solubility equilibrium concepts (F(1,57)=39.824, p<0.05). Table 2 demonstrated that there was no significant difference between the performance of males and females (F(1,57)=0.151, p>0.05). Also, there was no interaction between treatment and gender difference (F(1,57)=0.036 p>0.05). ANCOVA results of SECT are given in Table 2.

Table 2: ANCOVA Results of SECT

Source	df	SS	MS	F	p
Pre test (SCT)	1	331.371	331.371	39.824	0.000*
Group	1	183.117	183.117	22.007	0.000*
Gender	1	1.258	1.258	0.151	0.699
Group x gender	1	0.304	0.304	0.036	0.849
Error	57	474.291	8.321		

Total	62	31148.00

* Significant at $p<0.05$

The post-test average percent of correct responses of the experimental group was 78.7 and that of the control group was 69.7. When the proportion of correct responses and misconceptions determined by the item analysis for the experimental and control groups was examined, significant differences between the two groups in favor of the experimental were indicated. For example, when students were asked what happens when a small amount of salt which does not form compound with original salt solution added to original salt solution (Question 1). 92.6% of the students who instructed with case based learning answered it correctly by stating that the solubility of the original salt increases. However, as you saw on Table 3, 65.7% of the students who received traditional instruction answered the same question correctly after the instruction. The common misconceptions among control group students were that Ksp of the original solution does not change (16.1%), the solubility of the original salt decreases (10.3%), the added salt precipitates without dissolution (5.4%). However, 2.5% of the students held original solution does not change and the added salt precipitates without dissolution.

Table 3: Response Pattern of CG students on Question 1

	Control Group
Alternatives	Percent Correct
A	16.1
B*	65.7
C	10.3
D	5.4
E	2.5
Total	100

(*) Correct response

Further, students were asked what happens when salt solution is at equilibrium at 25°C, then temperatures drops to 15°C and its dissolution process is exothermic (Question 2). The desired response was that the ion concentrations increase. Although 85.2% of the students in the experimental group gave the correct answer, however, as you saw on Table 4, the percent of correct response for control group students was 68.6%. Some students (17.1%) in the control group held the misconception that temperature has no effect on solubility, the value of Ksp always decreases as temperature decreases. However 7.4% of the experimental group students held the same misconception.

Table 4: Response Pattern of CG students on Question 2

	Control Group
Alternatives	Percent Correct
A	17.1
B	7.4
C*	68.6
D	3.4
E	3.5
Total	100

(*) Correct response

When students were asked what the rate versus time graphic of salt solution is (Question 3), 85.2% of the students in the experimental group gave the correct answer that the rate of dissolution decreases and at the same time the rate of crystallization increases and at equilibrium the rate of dissolution and crystallization become equal. As you saw on Table 5, only 57.2% of the students in the control group answered it correctly. The common misconceptions related to this concept among control group students were that before the system reaches equilibrium there was no precipitation reaction (20%), the rate of dissolving increases with time from mixing the solid with solvent until equilibrium establishes (11.3%) at equilibrium dissolution stops (11.5%). However, 3.7% of the experimental group students held the misconception of before the system reaches equilibrium there was no precipitation.

Table 5: Response Pattern of CG students on Question 3

	Control Group
Alternatives	Percent Correct
A*	57.2
B	20.0
C	11.3
D	11.5
Total	100

(*) Correct response

Most students in control group couldn't understand what happens at equilibrium (Question 4). 31.5% students in the control group couldn't identify the equality of the rate of precipitation and the rate dissolution at equilibrium. However, 81.5% of the experimental group students responded to the same question correctly. As you saw on Table 6, 17.1% of the control group students answered that at equilibrium the concentration of solute and solvent became equal, 11.4% stated that at equilibrium there is no precipitation and dissolution, 3% stated that at equilibrium the mass of solute is greater than the mass of solution.

Table 6: Response Pattern of CG students on Question 4

	Control Group
Alternatives	Percent Correct
A	3
B	17.1
C	11.4
D*	68.5
Total	100

(*) Correct response

For an item which assessed students' understanding related to the effect of pressure and volume on solubility of salts (Question, 5), 81.5% of the students in the experimental group identified correctly that the change of pressure and volume does not effect if there is some solute at the bottom of the beaker. As you saw on Table 7, 65.7% of the students' responses in the control group were correct. 5.7% of the control group students believed that Ksp value should be known to answer this. Another common misconception among control group students (14.3% and 14.3%) was that the solubility of salt changes as the volume and pressure changes.

Table 7: Response Pattern of CG students on Question 5

	Control Group
Alternatives	Percent Correct
A	5.7
B*	65.7
C	14.3
D	14.3
Total	100

(*) Correct response

Students in the experimental group still have misconceptions about solubility equilibrium because misconceptions are very resistant to change even with instruction designed to address misconceptions and students persist in giving answers consisted with their misconceptions after a large amount of instruction (Fredette and Lochhead 1980; Osborne 1983; Champagne, Klopfer, Anderson, 1980; Anderson and Smith 1987; Wandersee et al., 1994).

3.1.2. Using Open Ended Solubility Equilibrium Concept Test as a post test

OSECT was criterion referenced interpretation in that students' score with subjective standard of performance are compared and not students' score with the performance of norm group. The reason for using criterion referenced is that content is narrow and so students will be able to understand all detail of the subject in that the amount of their understanding are determined. Also, students' lack points are easily determined. Using this test, students master a skill and demonstrate minimum acceptable performance. Maximum performance of students is measured and formative evaluation will be used for evaluation students' knowledge and they are able to transform solubility equilibrium concepts in to real life

situations. While evaluating students' responses, grade was between 0-3. Students got 3 if their responses include complete understanding statement(s). Students got 2 if their responses involve partial understanding statement(s). If students give the correct answer without any explanation or give some partial understanding statements(s) including some misconceptions. If students give correct answer but give wrong explanations (misconceptions), they got 1 grade. 0 was given if both statements and reasoning were wrong; means students still hold misconceptions about concepts.

The two-way analysis of covariance was conducted with treatment and gender differences as the independent variables, students' SCT scores as a covariate and OSECT scores as the dependent variable. Statistical analysis indicated that there was a statistically significant difference between the experimental and control groups' mean OSECT scores in favour of the experimental group (F(1,57)=27.174, p<0.05). The experimental group students scored significantly higher than control group students, X_{EG}= 60.10 and X_{CG}= 51.49, respectively. For example, when students were asked to graph and comprehend the solubility and precipitation rate of the salt at the beginning, before equilibrium and at the equilibrium. 70.4% of the students in the experimental group completely understand and gave desired answers; however, this kind of answer in the control group was 42.9%. Another question measuring students' understanding of common ion effect, in this question 66.7% of the experimental group students fully understand and mentioning the adding common ion changes the solubility. However, in the control group 37.1% of the students fully understand. 33.3% of the experimental group students showed partial understanding by giving only solubility changes with common ion but couldn't explain the rate of the solubility. However, this percentage was 57.1% in the control group. The students in the experimental group who were engaged in case-based learning instruction demonstrated better performance compared to the control group students who were engaged in traditional instruction. Also, the results showed that the SCT scores, means their prior knowledge, made a statistically significant contribution to understanding solubility equilibrium (F(1,57)=32.040, p<0.05). However, there was no significant difference between the performance of males and females (F(1,57)=3.167, p>0.05). Also, there was no interaction between treatment and gender difference (F(1,57)=3.639, p>0.05). ANCOVA results of OSECT are given in Table 3.

Table 3: ANCOVA results of OSECT

Source	df	SS	MS	F	p
Pre test (SCT)	1	1278.063	1278.063	32.040	0.000*
Group	1	1083.962	1083.962	27.174	0.000*
Gender	1	126.326	126.326	3.167	0.080
Group x gender	1	145.147	145.147	3.639	0.061
Error	57	2273.675	39.889		
Total	62	195200.000			

* Significant at p<0.05

Both open-ended and multiple choice concepts test results indicated that experimental group students performed well in comparison with control group students.

4. DISCUSSION

According to the results of the study, it can be concluded that case based learning instruction was more effective than traditional instruction in enhancing high school students' understanding of solubility equilibrium concepts. Thus, like Rybarczyk, Baines, McVey, Thompson & Wilkins (2007) and Kim & Hannafin (2011) studies, case based learning instruction was better than traditional instruction for elimination and remediation of misconceptions.

The reason of poor performance of the control group could be that traditional instruction was not focusing on students' misconceptions and concepts were presented in a logical sequence that is usually seen in textbooks. However, in experimental group, as Gallucci (2006) stated students' misconceptions were identified, conceptual framework was developed, and finally usage of metacognitive approaches

was integrated into cased based learning instruction. These properties of the case-based learning instruction may have led to a better understanding of solubility equilibrium concepts when compared to the traditional instruction. Like Gallucci's (2006) study, in this study case-based learning was helpful for remediation of misconceptions. The reason of this could be that experimental group students were instructed with cases emphasizing students' possible misconceptions, their prior knowledge, underlying concept and expected outcomes. In order to deal with misconceptions, like Gallucci (2006), students exchanged and differentiated their prior conceptions with new conceptions. Thus, by using case based learning instruction students observe and discuss real life situations and construct their conceptions. Therefore, students dealt with the misconceptions.

The similar misconceptions were observed using the open ended questions. Using open ended questions, the students' reasoning for their answers in the multiple choice questions was examined. Thus, students' understanding of solubility equilibrium could more deeply investigated by using open ended questions. Like Gaddis (2001) study, students showed misconceptions related to the molecular diagram of solution and the process of the formation of precipitation. Also, the experimental group students showed better performance for understanding and remediation of the solubility equilibrium.

Students demonstrated misconceptions on most of the topics in science, because science is related to life and so students usually develop some concepts without judging it scientifically acceptable or not. Chemistry is abstract subject and it includes mostly microscopic topics so it is also difficult to develop meaningful learning. Student could not observe some of the chemistry in the real world. Solubility equilibrium is one of the topics in which students could not develop meaningful connections among their connections and scientific conceptions. The reason of that could be that solubility equilibrium includes more concepts such as chemical equilibrium, solubility, molarity, nature of matter, Le Chatelier's principle. Thus, in order to construct meaningful learning for understanding of solubility equilibrium, students should first understand these concepts and then integrate these concepts for developing meaningful learning. Like Teichert, Tien, Anthony & Rickey (2008) suggested instructions should cover molecular-level descriptions of the concepts. Stories used in the instruction, could help students to understand the molecular level.

Misconceptions hinder students' learning, and Ausubel (1968) stated that in order to make meaningful learning, students need to form relations between ideas, concepts and information and also they need to make the linkage between concepts are interrupted. However, when students have misconceptions on some concepts like solubility equilibrium, students could not establish meaningful learning. Herreid (1994) stated that by using case based learning; students could link their prior knowledge with the new knowledge. Thus, in this study, students could link their existed solution concept with new knowledge and they developed deeper understanding of the solubility equilibrium and so they remediated misconceptions on that subject. The deeper understanding of solubility equilibrium by using case based learning instruction was obtained since this method promotes students' active participation and students analyze, examine and interpret the case together in group and then students solved the questions related to the case (Herreid, 1994). Thus, students constructed their own learning in class.

Students analyze and consider solutions of cases. Students' higher order thinking skills and teamwork abilities are improved (Herreid, 1994). Teachers could make use of cases through questioning, discussion in class by starting lesson with an open-ended question having definite and simple answer; this could be trouble but students could answer that question and then discussion is proceed and a product should be produced (Herreid, 1994). While conducting case- based instruction with small group activity; students make groups of students and they examined and interpreted that case together and then whether they solve the case related questions by theirselves (Herreid, 1994).

5. CONCLUSIONS

Case based learning method caused the better understanding of the solubility equilibrium concepts and remediation of misconceptions than traditional method. Case-based learning was administered by considering students' prior knowledge in solubility equilibrium. Cases were developed for revealing students misconceptions and after they were identified, by using small group discussion students' conceptions were constructed (Gallucci, 2006). The study revealed that students' prior knowledge made a statistically significant contribution to their understanding of solubility equilibrium concepts. Meaningful learning was established by the construction of new knowledge on the basis of what they

already know (Ausubel, 1968). As Ausubel, Novak & Hanesian (1978) stated students' made link between what students already know and new concepts. Also, students' prior knowledge was a significant source of learning difficulties (Hewson & Hewson, 1983) and it is best predictor of students' achievement (Staver & Jacks, 1988).

Teachers should be aware of students' misconceptions and so they should implement some teaching methods for remediation of students' misconceptions. In the case based learning method students work with their friends in the group and they discuss the case and the answers of the questions related to the case. Then, all of the students in the class discuss the case and they find out the answers of the questions. While using case based learning instruction, students' preconceptions were altered by using real life cases. Thus they could visualize the concepts and the concepts made sense easily since they most probably experienced before. Thus, students' misconceptions were remediated.

Since the students' prior knowledge and misconceptions strong predictor of achievement in science, teachers should be aware of this and should examine why these misconceptions occur. The main concern of the science teachers is the search for the efficient and enjoyable way of communicating chemistry concepts to students. This can be accomplished by devising new strategies and for them case-based learning is the one of the instructions for this. Thus, the other studies should investigate the case – based learning on different levels of students and its teaching formats such as discussion formats, debate format, public hearing format, trial format, problem based learning format, scientific research team format, team learning format should be administered to these students. Thus, whether there is difference among each formats could be found out.

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Genişletilmiş Özet

Öğrencilerin tutumları, yetenekleri ve deneyimleri onların öğrenmelerini etkiler. Ausubel (1968), öğrenmenin en önemli işaretinin öğrencinin derse gelmeden bildikleri olduğunu belirtmiş. Ancak, birçok araştırmacı öğrencilerin var olan bilgilerinin bilimsel görüşlerle farklılık gösterdiğini açığa çıkarmışlardır. Belli bir öğretim yöntemi uygulandıktan sonra bile öğrencilerde bilimsel görüşler ile kendi görüşleri arasında farklılık görülmüştür. Öğrencilerin kavramları anlamaları ve bilimsel olarak kabul görmüş anlamaları arasındaki farklılıklara kavram yanılgıları denilmektedir. Ancak bu, bilgi eksikliği veya yanlış tanım anlamına gelmez. Bunlar önceki bilgi ve deneyimleri doğrultusunda öğrencilerin yapılandırmış olduğu açıklamalardır. Öğrencilerdeki kavram yanılgılarını, kavramlar arasında tutarlı ilişkiler kurmakta ve kavramsal çatılar geliştirmekte yetersiz olan geleneksel yöntemle değiştirmek oldukça zordur. Kavram yanılgıları, öğrencilerin öğrenmelerini, kavramlar ve fikirler arasında ilişkiler kurmalarını ve kavramlar arasında bağlantı kurmalarını engeller(Ausubel, 1968). Bu yüzden, öğrenciler anlamlı öğrenmeyi gerçekleştiremezler.

Kimya, öğrenciler tarafından soyut ve zor olarak görüldüğünden öğrencilerde kimya konularında pek çok kavram yanılgısı olduğu ortaya çıkarılmıştır (Nieswandt, 2001; Chittleborough, Treagust & Mocerino, 2002). Bu kimya konularından bir tanesi de çözünürlük dengesidir. Çözünürlük dengesi konusu çözünürlük, fiziksel ve kimyasal denge, Le Chatelier prensipleri gibi kimya konuları ve ozmotik basınç ve ozmoz gibi biyoloji konularıyla alakalıdır. Bu nedenle öğrencilerin verilen konular arasında bağlantı kurması gerekmektedir. Yapılandırmacı araştırmacılar, öğrencilerin kendi öğrenmelerini kendilerinin yapılandırması için cesaretlendirilmesi gerektiğini belirtmişlerdir (Lockwood, 1992). Bu yaklaşıma göre öğrenci derste aktif olarak görev almaktadır.

Bu çalışmada, örnek olay yöntemi yapılandırıcı yaklaşıma göre sınıfta uygulanmıştır. Örnek olay yöntemiyle öğrencilerin derse aktif olarak katılımı sağlanmış ve kendi öğrenmelerini kendileri yapılandırmışlardır. "Örnek olay" diye adlandırılan mesaj içeren günlük olayla ilgili durumlardır. Örnek olaylar sınıfta dört farklı biçimde uygulanabildiği belirtilmiştir. Bunlar: bireysel ödev, konuşma şeklinde sınıfta aktarma, tartışma ve küçük grup etkinlikler (Herreid, 1994). Bu çalışmada örnek olay yöntemi küçük grup etkinlikle birlikte uygulanmıştır.

Çalışmanın temel amacı, örnek olay temelli öğrenme yönteminin onbirinci sınıf lise öğrencilerinin çözünürlük dengesi ile ilgili kavramları anlamalarına etkisinin geleneksel yöntem ile karşılaştırmaktır. Aynı öğretmenin iki ayrı sınıfı deney ve kontrol grubu olmak üzere rasgele atanmıştır. Deney grubu öğrencileri örnek olay yöntemiyle ve kontrol grubu öğrencileri geleneksel yöntemle öğrenim görmüşlerdir. Örnek olay yönteminin uygulandığı grupta çözünürlük dengesi konusunda gerçek hayatta ilgili durumlar sunulmuş ve öğrenciler küçük gruplar oluşturarak bu durumları incelemişlerdir. Bu durumlar öğrencilerin kavram yanılgıları düşünülerek geliştirilmiştir. Derse gelmeden önce öğrencilerden durumları okumaları istenmiştir. Sınıfta dört veya beş kişilik gruplar oluşturulmuş. Durumlar ve durumla alakalı sorular grup içinde tartışılmıştır. Durum, grup içinde tartışıldıktan sonra bütün gruplar, düşüncelerini ve durumun altında verilen soruların cevaplarını sınıfta paylaşır. Dersin sonunda ise bulgular ve öğrencilerin durum hakkındaki fikirleri tüm sınıf olarak tartışılır. Geleneksel yöntem uygulanan grupta öğretmen konuları öğrencilere anlatır, zaman zaman öğrenciler anlamadıkları kısımları sorar, öğretmen cevaplandırır. Bu yöntemde öğrenciler pasif dinleyici, öğretmen ise kavramları öğrencilere aktarıcıdır. Bu yöntemde de öğrencilerden derse gelmeden önce kitaplarından ilgili bölümü okumaları istenir. Sınıfta ise öğretmen anlatılacak konuyu tahta yardımıyla anlatır ve bazende öğrencilere konuyla ilgili sorular sorar. Öğretmen tahtaya sınıfta çözülen sorulara benzer sorular yazar ve öğrencilerden bir tanesi bu soruyu tahtada çözer. Dersin süresi 50 dakikadır. Bu uygulama altı hafta sürmüştür.

Uygulama esnasında uygulamanın öğretmen tarafından gerekli şekilde yapılıp yapılmadığını incelemek için araştırmacı iki sınıfı da öğretmenin haberi olmadığı zamanlarda ziyaret etti. Bu gözlemler sırasında öğrencilerin durumlara verdikleri tepkiler ve durumlarla çalışırken hevesli olup olmadıkları da gözlemlendi.

Uygulamanın başında öğrencilere çözünürlük kavram testi(ÇKT) ve uygulamanın sonunda çözünürlük dengesi kavram testi (ÇDKT) ve açık uçlu çözünürlük dengesi kavram testi (AÇDKT) verildi. ÇDKT ve AÇDKT yalnızca son test olarak kullanıldı çünkü uygulamanın başında öğrenciler çözünürlük dengesi konusuna aşina değillerdi. Bunun yanısıra ÇKT ön test olarak kullanıldı, çünkü öğrenciler müfredatta çözünürlük dengesi konusunu çözünürlük konusundan önce öğrenmektedirler. Böylece aynı iki testin çalışmanın başında ve sonunda uygulanmasından kaynaklanan test etkisi önlenmiş olmuştur. Uygulama sonunda öğrencilerin çözünürlük dengesi konusunu anlamalarını açığa çıkarmak için iki ölçek kullanılmıştır. Bunun sebebi öğrencilerin anlamalarının farklı yönlerden ölçülmesini sağlamak ve AÇDKT'de bulunan sorularda öğrencilerden sorulara verdikleri cevapların sebeplerini de belirtmelerini istemektedir. Böylece öğrencilerin verdikleri gerekçelerden kavram yanılgıları olup olmadığı belierlenmiştir.

Bağımsız grup t testi başlangıçta deney ve kontrol grubu arasında öğrencilerin çözünürlük kavramlarını anlamalarında fark olup olmadığını belirlemek için kullanıldı. Ön test analiz sonuçlarına göre; başlangıçta bu iki grup arasında çözünürlük dengesi anlamaları konusunda anlamlı bir fark bulunmamıştır. Uygulama sonunda ise çözünürlük dengesini anlamada yöntemlerin katkısı iki faktörlü ANOVA ile belirlenmiştir. Bu analizde yöntem ve cinsiyet bağımsız değişken, ÇDKT kullanılarak ölçülen öğrencilerin performansları bağımlı değişken olarak atanmıştır. Ayrıca öğrencilerin çözünürlük dengesini anlamada yöntemlerin katkısı açık uçlu sorularla ölçülmüş, iki faktörlü ANCOVA analiz yapılmıştır. Yöntem ve cinsiyet farkı bağımsız değişken, öğrencilerin ÇKT sonuçları kovaryans ve AÇKT sonuçları ise bağımlı değişken olarak atanmıştır.

Bu analizler sonucunda örnek olay yöntemi kullanılan öğrencilerin, çözünürlük dengesi kavramlarını, geleneksel yöntem kullanılan gruba göre daha iyi anladıkları tespit edilmiştir. Son olarak, öğrencilerin çözünürlük kavramlarıyla ilgili ön bilgileri, öğrencilerin çözünürlük dengesi kavramlarını anlamasında belirleyici bir unsur olarak karşımıza çıkmaktadır.