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Teaching Chemical Equilibrium by Analogy-Based Worksheets

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Abstract

Literature includes many studies based on analogies in which connections between target and source concepts were directly provided for students. However, in the current study, we tried to provide for them worksheets to apply analogies and encourage them to reach this relation network by themselves via following directions in the worksheets. Thus, the study aimed to reveal the effects of analogy-based worksheets about the chemical equilibrium on high school students' learning. A qualitative research method was used. The sample included twenty-five students at 10th grade from a high school located on the north east part of Turkey. Data collected via a Chemical Equilibrium Concept Test (CECT), analogy based worksheets and also non-structured observations. For the study, 'Chemical Equilibrium" was taught via two lessons plans including two analogy based worksheets. It is concluded that analogy based worksheets in which students were forced to connect old and new knowledge were quite effective to make students concretize and learn the chemical equilibrium concept as chemical equilibrium.

Key Words: *chemistry teaching, chemical equilibrium, worksheet, analogy*

Introduction

Literature about how individuals construct knowledge, which factors are effective in this process and how they achieve meaningful learning has continued to expand. In this context, educational studies have based on different learning theories. One of the popular learning theories of the 21th century without a doubt is constructivism supporting the view of individuals construct their own knowledge by making contact and coupling between their own knowledge in their mind and facing new knowledge. Witrock (1974) who is the most important supporter of the theory defined learning is a generative in nature. This generative learning model is "(a) the process of generating relationships or a structure, among the components, or parts, of the information one is trying to comprehend, and (b) the process of generating relationships between one's knowledge and the information one is trying to comprehend". Based on this model, meaningful learning occurs when the learner constructs his or her own meaning and understanding of the content by associating it with prior knowledge and experiences. In this reconstruction of the knowledge process students should join in to

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learning process actively, responsible from their own learning. Knowledge cannot be transfer from one source to another but meanings achieved by individuals. Thus, this generative learning model promotes instructional activities as being learner-centered, and asserts the learner "not as a passive recipient of information; rather, he or she is an active participant in the learning process…"(Lee & Grabowski, 2008, p. 112).

In this meaning construction process, teachers' duties and responsibilities have significantly changed. The most important change is instead of teaching students, teachers should provide all of the opportunities for learners' learning. Literature includes a lot of teaching and learning techniques which are used to support this process. One is analogies. Analogy is a cognitive process of transferring information or meaning from a particular subject (the analogue or source) to another particular subject (the target). Two concepts of analogy are source and target. The source explains known facts and concepts and the target explains unknown things. There are many descriptions including both concepts. These include; applying source concept characteristics to target concept (Blanchette & Dunbar, 2000), making a connection between known and unknown things (Baran & Çimen, 1999), comparing two unsure characteristics (Altan, 1998; Reinders, 1991), transferring relation systems from a known concept to an unknown one (Glynn, Gibson & Hawkins, 1996). Due to those characteristics, analogies could be used to teach science concepts for learners and also achieve meaningful learning by encouraging them making connection between a newly encountered concept and old knowledge.

Analogies in Science Education

Literature provided evidence about those using analogies in teaching processes for both teachers and learners. If an analogy, concerning to a concept could make a connection between newly learned concept and students' living environment and experiences, draw more interest (Theile&Treagust, 1994). In this way analogies, by increasing students' participation into lessons play an important motivated role in the learning processes (Dagher, 1995; Glynn & Takahaski, 1998; Thiele & Tregust, 1994). The nature of this technique includes students' connecting old and newly encountered knowledge. In this way the students can shape and model of science concepts in their minds more easily and thus they learned more consistently (Sarantapoulos & Tsaparlis, 2004; Stavy, 1991). There are many researches, which claimed that abstract concepts can be taught for students more easily by constructing analogies between concrete and abstract concepts (Dagher, 1995; Harrison & Treagust, 1993; Şenpolat, 2005). In this context, analogies provide student to realize their own misconception and help them to change them in a scientific way (Bilgin & Geban, 2001).

In this context, analogies are accepted as cognitive mechanisms for individuals to learn new concepts and making conclusion. Therefore, it is clear that students can use analogies when solving problems. In this way, they can more easily solve problems and, on the other hand, can also increase their problem-solving skills (Dilber, 2006).

Up to this point, we have mentioned about the analogies that they provide many advantages for learning and teaching. However, some studies hold the view that using analogies in teaching processes have some disadvantages. These include; in case of students cannot understand the dissimilar features of the source and target concepts, they could hold misconceptions (Coll, 2005; Bilgin & Geban 2001). In order to confront this problem, it is required to explain both similarities between source and target concepts and dissimilar features of them. Mapping similarities and dissimilar features between the source and target concepts are important to prevent misconceptions (Coll, 2005; Vural, 2005). It is important to use analogies which are relevant to the daily lives of students and also familiar with the earlier cases. In addition, source concept should be more simple and understandable than target concept. Its relationship of the target concept can easily be visible. Otherwise if students cannot make a connection between the source and target concept, they can fail (Coll, 2005).

Teaching the Chemical Equilibrium by Using Analogies

There are many studies in which students have difficulties to learn the subjects and concepts in chemistry field. One of those is noted as chemical equilibrium (Sepet, Yılmaz & Morgil, 2004; Quilez, 2004; Wheeler & Kass, 1978; Yıldırım, 2000; Yıldırım; 2009, Yıldırım and et al, 2011). Those studies showed that students had many misconception about the nature of equilibrium, equilibrium constant, the heterogeneous equilibrium, gases equilibriums and Le Chatelier principle (Akkuş, Kadayıfçı & Atasoy, 2003; Berguest & Heikkinen, 1990; Chiu, Chou & Liu, 2002; Gorodesky & Hoz, 1985; Huddle & Pillay, 1996; Hackling & Garnett, 1985; Kousthana &Tsaparalis, 2002; Piquette & Heikkinen, 2005; Thomas & Schwenz, 1998; Voska & Heikkinen, 1999; Van Driel, 2002; Yıldırım, 2000; Yıldırım; 2009, Yıldırım and et al, 2011).

The principal source of why students cannot understand chemical equilibrium concepts is believed that it is an abstract concept and thus students are failed to imagine events occurring at the time of equilibrium (Kousathana & Tsaparlis, 2002; Tyson &Treagust, 1999; Wheeler &Kass, 1978). To understand this topic, students should think about equilibrium event within macro, micro and symbolic levels (Wu Hsin-Kai, Krajick & Soloway, 2001). Chiu (2007) explained in his study that concepts are presented for students in macro levels and thus they stay stuck into it and cannot run into micro levels. Therefore, for students in order to understand this concept in three levels we need for materials which make it concrete. To this end, for students to understand equilibrium concept in three levels, analogies were used in many studies (Bilgin & Geban, 2001; Bilgin & Geban, 2006; Chan, Pınarbaşı, Bayrakçeken & Geban, 2004; Harrison & Buckley, 2000; Harrison & Jong, 2005; Locaylocay, 2006; Sandberg & Bellamy, 2004; Sarıçayır, Şahin&Üce, 2006; Russel, 1988; Weerawardhana, 2003; Weeradwardhana, 2006; Wilson, 1998).

One of them is enhanced by Russell (1988) 'Water Tank Analogy (Liquid Transfer Model). In this analogy, transfer of the two measuring cylinders is liked to events in the process of equilibrium. In the literature, similar to this analogy, Harrison and Buckly (2000) used coins instead of water, Wilson (1998) used matches. Sarıçayır, Şahin and Üce (2006) in their study developed a computer animation which is like to Harrison and Buckly's (2000) analogy.

Harrison and Buckley (2000) in their study wrote reaction equation of A (aq) $\longleftrightarrow$ B (aq) and while putting 24 students under A as presenting reacting item, on the other hand they put no students under B by means of no products at the beginning. Then for every minute student were encouraged to think and make tables on the board half of reactants to products and ¼ of the products to reactants. The third minute data shows the dynamic equilibrium. A similar analogy was done by Wilson (1998) via 40 matches. From moving the view of these analogies will help students' understand equilibrium moment in a molecular structure; Sarıçayır and colleagues (2006) developed a computer program. In the program, they used a similar analogy as to Harrison and Buckley's (2000) ones. In this program there is a half spitted box on the first pane of computer screen and it includes 24 atoms numbered from 1 to 24, representing reactants (atoms, in the form of circles). The second pane does not include anything because reaction does not start. In addition, there is a table which shows the change of atoms in both panes per two minutes. When students toggle button for the first minute, 12 atoms pass to B pane. Then, later when they press the button for each minute, half of the reactants to products and ¼ of products transforms to reactants. Students see atom quantity from both box and tables. By the third minutes ended, there is no change in the numbers of reactants and products. Here researchers warned students about that 'when the system reaches a equilibrium, concentration of reactants and products are not change but microscopic events still go on'.

In other study, Canpolat (2002) used Russell's (1988) analogy called 'water tank analogy'. When making the application, he used two 100 ml measuring cylinders, two different volumes of the pipettes and a colored liquid. He puts a colored liquid to about 100 ml to one of the measuring cylinders; the other measuring cylinder is initially empty. Initially the measuring cylinder including colored liquid represents reactants and the other empty one represents products. Each pipette is immersed to each measuring cylinders and liquids in the measuring cylinders are deflated mutually opposite measuring cylinders (flowing liquid volume from pipettes shows reaction speed). The volume of the fluid at a given time in the measuring cylinder represents current products and reactants' concentration. By this way, the reaction process is started. At this time, students are asked questions about the analogy (Is it possible to flush the liquid in the first measuring cylinder to the second one? How much liquid can be transferred?, How will you understand in this model to reach a equilibrium? What is the thing of equal in equilibrium?). In this analogy, two volunteers make on the operations and write the volume of the liquid on the board. And despite a period of time to fluid liquid transfer, it is seen that fluid levels remain unchanged. Then graphics are drawn based on the data on the board and change forward and backward reaction rate over time and also reactants and products concentration showed on the graphic. In addition, each student is asked to draw graphs based on data on the board.

In these studies (Canpolat, 2002; Harrison & Buckley, 2000; Wilson, 1998), connections between target and source concepts were directly provided for students. However, in the current study, we provided them worksheets to apply analogies. They reached this relation network by themselves by following directions in the worksheets. In this sense, students are forced to connect old and new knowledge (Akkuş, 2004; Bilgin, 2005). Chiu and his colleagues (2002) showed that activities in which students actively constructed knowledge is most effective to learn. In this way students constructed easily relation between source and target concepts. In addition, via analogy maps student can compare similar and dissimilar properties of source and target concepts. Harrison and Treagust (1993), also explained that while using analogies, differences between source and target concepts will avoid their developing misconceptions while constructing concepts.

This study aims to evaluate the effects of chemical equilibrium worksheets based on the water tank analogy on students' leanings of chemical equilibrium.

Method

Sample

This study included twenty-five 10th grade high school students who studied at a public high school in Trabzon.

Data Collection

Data collected by using a Chemical Equilibrium Concept Test (CECT), two chemical equilibrium worksheets based on analogy and also unstructured observations during intervention.

Chemical Equilibrium Concept Test

This test included four questions and developed by the researchers. Its content validity was provided by experts in the field of chemistry and also chemistry education. It was applied for five high school students. These students not only answered the questions but also were asked to explain if there was an unread and/or incomprehensible sentence. Based on students' feedbacks, it was developed. Table 1 below shows questions and their content.

Table 1.
Questions in the Chemical Equilibrium Concept Test

Question Number	Content of the questions
1	It consists of two phases. In the first stage, reaction occurring in the car battery is explained then they are asked to consider similarities and different points between this event and ammonia process. In the second stage, in a similar manner burning reaction in car motor cylinders is explained and they are asked to consider similarities and different points between this event and methane gases burning reaction.
2	They are provided a reaction of gaseous hydrogen and iodine combining to create a reaction of hydrogen iodide and they are asked to draw which items in the reaction container for three times, before reaction started, at the equilibrium time and after the equilibrium.
3	They are asked to draw and explain concentration of reactants and products for provided equilibrium reaction until it come up with equilibrium by using concentration-time graph.
4	They are provided two concentration-time graphs for two reactions and asked to consider on the similarities and different points about these two reaction graphics.

Analogy Based Chemical Equilibrium Worksheets

Two worksheets about chemical equilibrium were developed by the first researcher. These are (i) one and two ways reactions and (ii) characteristics of two ways reactions". Misconceptions about the chemical equilibrium concept were also considered. They included daily examples and also water tank analogy. Pilot studies were also conducted with 20 grade 10 students from a general high school. Based on the observations during application process, the data obtained in accordance with the opinions of the two chemistry teachers working in the same schools, worksheets were given their final version. Their contents are briefly described below.

(i) One-Two Ways Reactions Worksheet

This worksheet aims to differentiate between one and two ways reactions and attracts students' attention towards these reactions' role in daily life. For this purpose, the worksheet includes some events from daily life like damages that may arise as a result of the mixing of cleaning items next to each other, blood oxygen transporting, melting the ice in an open bowl and water evaporation in a closed container. Then, students are asked about those events and seeing the differences between physical and chemical reactions and one-way and two-ways reactions.

(ii) Characteristics of Two Ways Reactions Worksheets

This worksheet aims to inform students about the events during two ways reaction process, such as equilibrium the moment, conservations changes of reacting and products in equilibrium, and also changes of forward and backward reaction rates. For this purpose, two activities related to water tank analogy (WTA) were used in active occupational section of this worksheet.

For the first activity, students were provided a measuring cylinder full of water representing a reaction starting via A matter and an empty measuring cylinder representing reactant. For the second activity, we explained that we will investigate the events when B matter is constructed. For this analogy, there are two measuring cylinders one is full of orange colored solution and the other is with water. Then, we provided them processes about the analogy. First measuring cylinder acted for reactant and the other reductant. By the analogy, an amount of water (1/2) is taken to the second measuring cylinder and an amount of solution (1/4) was taken to first measuring cylinder. In this process, amount of transferred liquid and liquid amount in the measuring cylinders were recorded on a table. This task was repeated for seven times. Then, moving from the table students were asked some questions (Appendix 1).

In this analogy, as similar to Canpolat's (2002) study, liquid volume come from pipettes represented reaction rate, liquid volume in measuring cylinders any time represented concentration of reactants and reductant. During the equilibrium while going on to liquid transfer, however liquid amount in the measuring cylinder does not change. This situation is looked like conservation of reactant and reductant does not change after equilibrium time. In this study for the second activity in the worksheet, while we used a colored liquid and also water, when liquid transfer started liquid colors in the measuring cylinder s changed (at the beginning measuring cylinder full of water were uncolored but then changed to yellow, and liquid color in the orange color changed to yellow), however in the equilibrium time it does not change were related to after equilibrium concentration of A and B matter does not change. Wilson (1998), Harrison and Buckley (2000), Canpolat (2002), Sarıçayır and colleagues (2006) explored that students understood that in the equilibrium time reactant and reductant conversations not change, from the fact of after three minutes from top numbers, matchbox numbers and also liquid amounts stable.

Lesson Practices

The worksheets were implemented by a chemistry teacher and took five weeks. In order to guide him, two lesson plans were also used. The first researcher has been involved in the classroom and observed about the practices. Before each lesson, they, researcher and the teacher explored again in detail in lesson plans and worksheets. The first worksheet was implemented at the beginning of the chemical equilibrium unit. Then the teacher has taught maximum irregularity and minimum energy trends topics, then the second worksheet has been applied. Lessons have started by asking the questions in the first section of the worksheet. Their answers were taken without sharing their scientific answers, and they are explained to find answers by following the process steps. Students into groups of 4 or 5 performed processes in the occupational section of worksheets. This time the teacher, by traveling around between groups guided them with questions. Students who finished this part of the study, answered about the questions on the evaluation part of worksheet and finished it. The second lesson, the teacher asked the students again about what they did on the worksheets in the first lesson. Then he completed the shortcomings and provided the required knowledge. After the implementation of the second worksheet that used anology, the teacher showed anology map to the students and explained the similarities and different points between the analogy and the subject, and also sum the basic topics. At the end of the course, questions at the end of the lesson plan were asked to the students.

Data Analyses

CECT was implemented before one week teaching chemical equilibrium unit as a pre-test and after one week when it finished as a post- test. Questions on the worksheets and CECT were coded as correct, partly correct, wrong and no answer by researchers as in the study done by Coştu, Karataş and Ayas (2003). Table 2 shows how it was analyzed. Semi-structured observation data were analyzed by using descriptive analysis.

Table 2.
Data analyses categories and contents

Correct	Students' answers which contain all the aspects of the answer that is valid and consistent with the scientific information has been included to this category.
Partly correct	Students' answers which contain one or more direction and superficially expressed ones have been included in this category.
Wrong	Non-scientific or inconsistent with scientific knowledge student answers have been included in this category.
No answer	Leave blank or verbatim or partly repeated questions have been included in this category.

Results

The study results were presented via three subheadings sequenced as CECT, Worksheet and also Observation results.

CECT Results

The students' answers about the questions in the CECT were analyzed under the categories of correct, partly correct, wrong and no answer. Table 1 shows frequency of students' answers about both pre and post tests.

Table 3.
Distribution of students' answers according to categories of the pre-post tests

Question number	correct		partly correct		wrong		no answer	
	Pre test	*Post test*	Pre test	*Post test*	Pre test	*Post test*	Pre test	*Post test*

	f	*f*	f	*f*	f	*f*	f	*f*
1a	7	*7*	8	*10*	7	*5*	3	*3*
1b	6	*10*	6	*11*	6	-	7	*4*
2.	-	*12*	-		14	*9*	11	*4*
3.	-	*10*	-	*11*	11	*4*	14	-
4.	-	*20*	-	-	18	-	7	*5*

For the pretests, table 3 shows that seven subjects answered as correct, and eight one as partly correct for the question number of 1a. However, after the intervention, seven subjects answered similarly as correct, but ten one as partly correct for the question number of 1a. This result clarifies that only two students changed their views from wrong towards partly correct on the 1a question. On the other hand about the question of 1b, at the beginning six subjects answered as correct and also six one answered as partly correct. However, after the intervention, ten subjects answered as correct and eleven one as partly correct for the question number of 1b.

This data explains that nearly 50% of the subjects changed their views from wrong to partly correct or from partly correct towards correct views. Based on this data, it can be claimed that students could distinguished which of the events were one way and which were two way reactions, and also they usually expressed this is sourced from this reason of chemical reactions. However, they used only one way and two way (alternating-recyclable) concepts and did not made detailed explanations. This situation shows that students could not understand the state of being reversible of chemical equilibrium reactions. This result is also parallel to the literature (Berguest & Heikkkinen, 1990; Crosby, 1987; Hackling & Garnett, 1985). The number of students who answered as correct or partly correct to the first question increased. This may sourced from a research work for student to perform within the lesson of second worksheet implementation. In this work, students were informed to research on three events in which included two way reactions.

The second question in which students drew which of the substances appeared in the reaction container for a two way reaction ($H_{2(g)} + I_{2(g)} \leftrightarrow HI_{(g)}$) was answered as wrong by fourteen students and also eleven students did not answer. None of the students also answered as correct or partly correct about the question at the beginning. Students in the wrong drawings generally drew hydrogen and iodide molecules in the reaction container before reaction started and also in the equilibrium time, and only hydrogen iodide after the equilibrium. This may sourced from that students studied only one way reactions in their teaching program. Twelve students answered as correct, nine as wrong and four as blank at the post test. Students who answered as correct drew hydrogen and iodine molecules before starting the reaction in the container, and drew each of the three molecules after equilibrium. Some students at the time of the equilibrium and after it drew hydrogen iodide in the environment. In addition, nine students drew similar wrong drawings about the fourth question of two way equilibrium reactions. This may sourced from that of students may consider the reactants in the reaction completely spent. There are similar errors in many studies of the literature (Berguest & Heikkinen, 1990; Huddle & Pillay; Voska & Heikkinen, 2000; Yıldırım, Bak &Ayas, 2007; Yıldırım; 2009, Yıldırım and et all, 2011). This is why students cannot pass from one-way reactions to two way reactions and also theystil have misconceptions after analogy based teaching. It is a fact that misconceptions are resistant to change even after a constructed teaching (Bilgin & Geban, 2001). However, the fact of that thirteen students answered as correct in the worksheet implies that analogy used in the study is quite effective to teach event during at the time of eqilibrium about 50%.

Third question was also answered as wrong by eleven students and fourteen of them did not answer at the beginning. In addition none of the students also answered as correct or partly correct about the question at the beginning. However, at the end ten students answered as correct and eleven one as partly correct. Four students still hold the wrong answer. Lastly, fourth question was answered as wrong by eighteen students and also seven of them did not answer. In addition none of the students also answered as correct or partly correct about the question like second and third question at the beginning. However, at the end nearly all the students except for five ones answered as correct. Five students did not answer the question.

Worksheet Results

Table 4 shows the categories of students' answers for the questions in the One-Two Ways Reactions worksheets.

Table 4.
Categories of students' answers about the questions within the one-two ways reactions worksheets

Question number	correct	partly correct	wrong	no answer
	f	*f*	*f*	*f*
1.	*21*	*4*	-	
2.	*20*	*4*	-	*1*
3.	*18*	*4*	*2*	*1*
4.	*23*	-	-	*2*
5.	*15*	*8*	-	*2*

Table 4 shows that most of the students provided answers categorized under the correct or partly correct. Table 5 shows the categories of students' answers about the questions within the Two-Way Reactions worksheets.

Table 5.
Categories of students' answers about the questions within the Two-Ways Reactions worksheets

Question number	correct	partly correct	wrong	no answer
	f	*f*	*f*	*f*
1.	*20*	-		*5*
2.	*13*	*8*	*2*	*2*
3.	*17*	*5*	*1*	*3*
4.	*14*	*6*	-	*5*
5.	*13*	-	*9*	*3*

Table 5 shows that except for fifth questions, students were mostly provided correct or partly correct answers. However, fifth question was answered as correct by thirteen students and as no answered by nine ones.

Observation Findings

The students' behaviors during worksheet practice was recorded and listed below via a control list.

Number	*Students Behaviors*	*Observed*	*Not observed*
1.	Students were often willing to participate in the discussions	✓	
2.	The discussions revealed students' prior knowledge on the subject	✓	
3.	Students often asked questions during the discussions	✓	
4.	Discussions increased students' curiosity and interest in the new issue	✓	
5.	Students were willing to make the activities	✓	
6.	Students made task-sharing within the groups	✓	
7.	Teacher asked questions to guide students toward to a conclusion by walking among the groups.	✓	
8.	Teacher used different sources during activities		✓

9.	Teacher made statements to help students	✓
10.	Student asked questions to practice what students have learned to different situations	✓
11.	Gifted students in the classroom were foreground when teacher asked questions.	✓

Discussion and Conclusion

Eleven students drew wrongly the concentration-time graphics of two ways reactions at the third question and did not provide any explanations about it. Similarly, students mostly answered as wrongly on the two concentration-time graphics at the fourth questions the one and two ways reaction (18 students). That of students could not provide correct answers about the questions in which basic characteristics about the two ways reactions were asked, sourced from their not seeing it before. However at the post tests, about the third questions, 10 students answered as correctly, 11 as partly correctly and 4 is wrongly. While analyzing students' graphics on these questions, it was found out that some students could drew changing correctly during reaction period about N_2O_4 and NO_2 concentration. However, they could not name the X and Y coordinates of the graphs. Similarly, some made the naming and how to matter change but did not show which change belongs to which matter. These kinds of answers were evaluated in partly corrects categories. For the fourth questions, 20 students were answered as correct, 5 was wrongly at the post tests. This can be assessed that by the analogy based instruction students could differentiated between one and two way reactions.

This may cause from an effect of 'one way and two way reactions' worksheets. Because, Table 4 showed that students mostly answered as correctly to the questions of the worksheets' evaluation part. Based on this data, we think that developed worksheets would be effective for students to be aware of two ways reactions than one way reactions. From observation notes, it is concluded that students developed in this direction. Literature also supported the view that worksheets let students to learn science concepts (Özmen &Yıldırım, 2004).

By the examination of the students' answers to the questions of the second worksheets' evaluation part (in which back and forth reaction equations required to be written), twenty of them provided correct and five students provide no answer. The majority of students' question to be answered correctly showed that students understand the relationship between forward and backward reactions by the analogy (Baran & Çimen, 1999). This is important for students to understand this relation at the beginning of the analogy for understanding the following relations about equilibrium time. Otherwise, a wrongly understood analogy may cause a wrong idea for students (Glynn, 1995).

By the students' tables about the second worksheet related to analogy, 13 students provided correct, 8 partly corrects and 2 wrong related to the question which chances are occurring in the rate of the forward reaction. In addition, 2 students provided no answer. In the data analyzes process, students' answers of which explained initially, the forward reaction is fast, and backward reaction is slow, and over time these rate are synchronized or only one time later they are synchronized, were in the category of partly correct. Two of these students answered as amount of transferred liquid decreased in the forward reaction, increased in the backward reaction, after one time synchronized. This may be caused from the nature of the question as "based on the liquid amounts transferred". This may be the result of students' answering the questions in the worksheets unconsciously and without thinking to mechanically. This fact then cause student cannot connect the relation between analogy and reality (Treagust, Harrison &Venvile, 1996). This issue corrected after the worksheets. Any incorrect application when using the analogy, can adversely affect subsequent units as a rock chain. Because, equilibrium concept is a basic concepts for the later units such as resolution equilibrium and acid-base equilibrium (Yıldırım et al., 2007).

For the question of concentration change of matters in the process of reaction, 17 students provided correct, 5 partly correct and 1 wrong. In addition, 3 students no answer. Partly correct category included the answers of concentration does not change and fixed. The fact that of students' responses mostly included analogy based explanations shows that used analogies let students understand the changes of concentration in the process of equilibrium (Clement, 2002; Sağırlı, 2002;

Şenpolat, 2005; Vural, 2005). There are many studies in which analogies help students to learn scientific concepts (Bilgin & Geban 2001; Coll, 2005; Vural, 2005). Not only but also students' learning active collision theory within rate in the chemical reactions before this unit let students provide correct answers for this question (Alkan & Benlikaya, 2004).

For the question of which matters are there in the process of equilibrium by using analogies, 14 students provided correct, 6 partly correct and 5 no answer. The aim of using different colored liquid for the analogy is to show students both matters are in the reaction cap. In addition, we waited from students construct the relation between no colored difference after equilibrium and observable events lasted but reaction goes on. While students answering these questions, teachers help time by asking some questions as what matters are there in the reaction cap?, did reaction lasted from here? Does only forward reaction occur? In this way students constructed the relation between analogy and reaction. Most of the students provided correct answers to those questions. It can be said that follow analogy after equilibrium let students learn that observable events lasted after equilibrium but forward and backward reaction always go on. This supported the view that analogies are effective tools to teach concrete concept and topics like chemical equilibrium for students (Clement, 2002; Coll, 2005; Chiu & Lin, 2005; Dagher, 1995). Water tank analogy by this way is effective to teach equilibrium concept to students.

Implications

By using analogies, similar and dissimilar properties between analogy and target concepts should be given as well. Firstly, the teacher asked to the students of worksheet end questions again after applying the second worksheet. Taking their responses, he showed the analogy map and explained the similar and dissimilar properties between analogy and equilibrium of two ways reactions. In this way nearly all students constructed the relation between analogy and equilibrium. It is also important to explain student the relation between the reality and analogy. Otherwise, students may mix the reality to analogy and have some misconceptions (Coll, 2005; Vural, 2005). For the real application, one hour period is enough however one hour is not. This implies that by accustoming to these kinds of studies students use time more effectively and gain regular work habits. In this way the current work helped students to move as a group. Because during analogy application period students made the exchange of ideas with each others. It is supported to view that both worksheets and analogies attracted students' attention and effective in students' both cognitive and emotional learning's (Özmen & Yıldırım, 2005).

This study also supported the view that analogy based worksheet can help students concrete the events among equilibrium and learn this concept conceptually. For that reason, teachers should be encouraged to use analogies and worksheets during teaching period. In the study, water tank analogy was implemented successfully and it is time to develop worksheets about the factors on equilibrium. Students have both learned and had fun by the analogy worksheets. They were eager to join to the debate. While working in groups they helped each other's. This case supported the view of worksheets and analogies let students' motivations increase and encourage their joining in to the lessons. As parallel to this result, their achievement increased for the last test (Dagher, 1995; Glynn & Takahaski, 1998; Thiele &Tregust, 1994).

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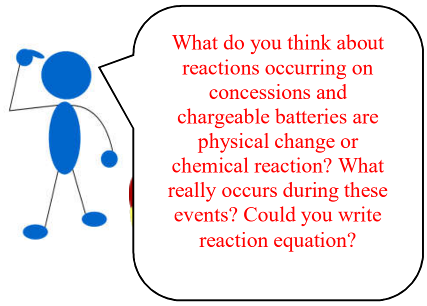
Appendix. Two Ways Reactions Worksheet



Concession

Reaction on chargeable batteries

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Let us look at the following reactions.

Materials: Potassium chromate inhibitors solution, Potassium dichromate solution, HCI solution, NaOH solution, 5 measuring cyclinders

Procedures:

1. Put 10 ml of K_2CrO_4 (Potassium chromate inhibitors) into one and 10 ml of $K_2Cr_2O_7$ (Potassium dichromate) solution into other measuring cyclinders. Save colors.

....
....

2. Put in a few drops HCl solution into both measurement cyclinders. Save the changes that occur and complete the reaction equations about the event.

$CrO_4^{-2} + H^+ \rightarrow$ ...... + ...

$Cr_2O_7^{-2} + H^+ \rightarrow$ .... + ...

....
....

3. Put in a few drops NaOH solution into both measurement cylinders. Save the changes that occur and complete the reaction equations about the event.

$CrO_4^{-2} + OH^- \rightarrow$ ...... + ...

$Cr_2O_7^{-2} + OH^- \rightarrow$ .... + ...

....
....
....

4. Put the matches on the table into beherglass (do not attempt to burn it outside of beherglass). Write the equation of combustion reaction of the matches.

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……………………………………………………………………………………………………
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Now, discuss and answer the questions by group with your friends.

1. What is the cause of color changes that occur in the second and third steps? Explain by writing reaction equation.

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2. Can we get matches again after fourth step? Explain your answer with reasons.

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3. What are the similarities and differences about the burning reaction of matches on second and thirds steps?

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4. Reaction equation about second and third steps are written below;

$$2CrO_4^{-2} + 2H^+ \rightleftarrows Cr_2O_7^{-2} + H_2O$$

Based on your actions write back and forth reaction equations for above reactions.

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……………………………………………………………………………………………………
……………………

5. **I.** $C_{(g)} + O_{2(g)} \longrightarrow CO_{2(g)}$
   II. $N_{2(g)} + H_{3(g)} \leftrightarrows NH_{3(g)}$

In accordance to obtained results based on experiments you did, explain why there is one single arrow in the first but there is double arrows in the second equations above via their reasons.

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