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THE EFFECT OF LABORATORY METHOD ON HIGH SCHOOL STUDENTS' UNDERSTANDING OF THE REACTION RATE

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Abstract

In science education, laboratories are considerably important because they provide the opportunity for students to perform various hands-on activities. The aim of this study is to investigate the effect of laboratory method on students' understanding of the subject of rate in chemical reactions. With this aim, a control group (12 boys, 5 girls) and an experimental group (10 boys, 9 girls) were randomly selected from an Anatolian high school in Trabzon. The study was used a quasi-experimental design. Two different instruments pre-test and post-test were used to collect the data in the present study. While the pre-test consisting of 19 multiple choice items was applied to determine students' preconceptions about the topic under the investigation three weeks before the treatment, the post-test with 19 multiple choice items was implemented to their new levels of understanding two weeks after the treatment. Two master faculty members examined the tests that were piloted with 40 students. Reliability coefficients (KR-20 method) were found 0,79 for the pre-test and 0,70 for the post-test. The experimental group was taught with a teaching method based on laboratory while the control group was taught by the traditional approach. The collected data were analyzed by using the independent samples *t* test. The results showed that there is a significant achievement difference between the experimental group that was taught with the laboratory teaching method and the control group that was taught with the traditional approach in favor of the experimental group ($p<0.05$). Nowadays, it was expected the learner to have ability of reaching, rearranging, evaluating and presenting of information. In this respect, it is suggested to quite often use the laboratories in a more active manner.

Keywords: Chemistry Education, Reaction Rate, Laboratory Method.

INTRODUCTION

In science education, laboratory work is considerably important because they provide the opportunity for students to perform various hands-on activities. There have been many studies reporting on the effectiveness of the laboratory instruction on students' understanding of science concepts (e.g., Lazarowitz & Tamir, 1994; Hart et al., 2000; Özmen et al., 2009). Also, many researchers believe that laboratory work helps promote conceptual change (Demircioğlu, 2003; Özmen et al., 2009) and is motivating and exciting for students (Markow & Lonning, 1998; Hart et al., 2000).

Chemistry is a difficult subject for secondary school students to learn (e.g., Taber & Coll, 2002; Demircioğlu, 2003). Teachers also find some chemistry topics difficult to teach. One reason of this is that chemistry concepts are abstract in nature and require students to construct mental images of things they cannot see (Taber & Coll, 2002). Another reason is that a chemical phenomenon requires understanding both macroscopic and microscopic level. The interactions and distinctions between the levels are important necessary for comprehending chemical concepts (Sirhan, 2007). Because of the reasons mentioned above, students at all levels of education have many misconceptions in chemistry and they has been well documented in the literature (Ben-Zwi et al, 1986; Demircioğlu,2003; Özmen et al., 2009). One of these chemistry concepts is the reaction rate. There is very little research about the students' understanding about the reaction rate. Chuephangam (2000) investigated students' conceptions of the reaction rate and found that about 12 to 22 percent of students had alternative conceptions. Kousathana and Tsaparlis (2002) argued that many students failed to grasp that reaction yield and reaction rate are different concepts. Griffiths (1994) reported that most secondary school students had problems in discriminating the reaction rate and the extent of reaction. Similarly, Aydin et al. (2009) found that students had difficulty in discriminating the rate of reaction and the chemical equilibrium concepts. Bozkoyun (2004) investigated the effect of combination of conceptual change texts and analogies on 10th grade students' understanding of reaction rate and found that the method caused higher success than the traditional approach. In the literature, researchers have used a variety of interventions to improve student learning in chemistry. We used the laboratory activities in the present study to improve students' understanding of the reaction rate. The purpose of this study is to investigate the effect of laboratory method on students' understanding of the rate of chemical reactions.

METHOD

The quasi-experimental design was used in this study. The study was conducted in one of the Anatolian High Schools in the city of Trabzon. 36 11th grade students from two classes in a secondary school voluntarily participated in the study. One of the classes was randomly assigned as the experimental groups (10 boys, 9 girls) and the other as the control group (12 boys, 5 girls). Each teaching approach used in the study was randomly assigned to each class. Both groups were taught by a chemistry teacher with 20 years of teaching experience. In the experimental group, students were taught with laboratory experiments which were prepared by the authors. While developing the experiments, it was benefit from various chemistry books (e.g. Nazlı, 2002; Dursun et al., 2010). Four experiments were developed. These are; "Does the rate of a reaction depend on the interacting surface area?"(Exp 1), "Does the rate of a reaction depend on the concentration?" (Exp 2), "How does a catalyst affect the reaction rate?" (Exp 3), and "What is the effect of temperature on reaction rate?" (Exp 4). Experiment 1 is given in the Figure 1 as an example of experiment design used in the present study. The experimental students work in the groups of 6 to 7 members to perform the experiments. They discussed and answered the questions at the end of the experiment worksheet within their group. Then each group presented its results to entire class. While the students were performing the experiments, the teacher walked around inside laboratory and helped them if they needed. In the control group, the students were taught by teacher-centered approach. The students listened to the teacher's lecture and took notes. After the teacher's explanations, some of the concepts were discussed.

Experiment 1: Does the rate of a reaction depend on the interacting surface area?
Purpose: To observe the effect of the interacting surface area on the reaction rate
Equipment and materials: Test tube (2), hydrochloric acid (6M), chalk powder, a lump chalk (or marble), distilled water.
Procedure

a. Label the test tubes as 1 and 2. Put about 0,5 cm depth of powdered chalk in tube 1 and lump of chalk in tube 2. Add 3 ml depth of distilled water in each tube.
b. Take tube 1 and shake it to get suspension of powdered chalk. Pour 2 mL the hydrochloric acid into tube 1 and record your observations in the following table.
c. Pour 2 mL hydrochloric acid into tube 2 and record your observations in the following table

			Note your observation
Tube 1	Chalk powder	Water + HC1	
Tube 2	Lump of chalk	Water + HC1	

Evaluations and Conclusions

1. How does the surface area affects the reaction rate? Explain.

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2. How can the surface area of substances be increased? Explain.

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Figure 1. An example of experiment design used in the present study.

Data Collection Tools

In this study, it has been used two different tests, "*Reaction Rate Diagnostic Test* (RRDT)" and "*Reaction Rate Achievement Test* (RRAT)", to collect the data. RRDT consisting of 19 multiple-choice items has been performed as pre-test to explore students' preconceptions of the reaction rate three weeks before the treatment, and the other consisting of 19 multiple-choice items as post-test to determine their new levels of understanding about the concepts under investigation two weeks after the treatment. The authors developed both tests by taking into account 11th grade chemistry curriculum and chemistry textbooks. For validity of the tests, they were examined by two master faculty members and were piloted with 40 students. Reliability coefficients (KR-20 method) were found 0,79 for the RRDT and 0,70 for RRAT. The conceptual areas covered by the tests were presented in Table 1.

Table 1. The conceptual areas the each test item attempts to measure

Subject areas	RRDT (item no)	RRAT (item no)
Surface area on reaction rate	2, 7, 11, 18,	4, 9, 12, 19, 17
Concentration on reaction rate	4, 6, 9, 16, 19,	2, 3, 8, 11, 16
Catalyst on reaction rate	1, 8, 12, 13, 14	5, 6, 10, 13, 14
Temperature on reaction rate	3, 5, 10, 15, 17	1, 7, 15, 18

Data Analysis

In scoring both the RRDT and the RRAT, each correct response was scored with 1 point, while each wrong one was scored with zero point. Thus, for each test the maximum score was 19 points. Independent t test was used to compare the RRDT results. The analysis of covariance (ANCOVA) was used to compare the post-test scores, with the teaching methods used in both groups as the independent variable, the pre-test scores as a covariate and the post-test scores as the dependent variable. ANCOVA takes into account the differences between the pre-test means of the groups to compare their post-test scores.

FINDINGS and DISCUSSION

The RRDT scores and the RRAT scores for the experimental and the control groups are presented in Table 2, which shows that control group (M =3,76; SD =2,07) have a higher mean than the experimental group (M = 2,74; SD =1,88). The results of t-test towards pre-test scores indicated that there was no statistically significant difference between groups (t = 1.56, df = 34, p>0.128). This indicates the similar backgrounds of the both group students in respect to reaction rate before the treatment. To test the effect of the treatment, the ANCOVA analysis on post test scores is summarized in Table 2.

Table 2. Summary of ANCOVA on students' post-test scores

	Experimental Group (n=19)			*Control Group (n=17)*				
	M	*SD*	*Adj. Mean*	*M*	*SD*	*Adj. Mean*	*F*	*p*
Pre-Test (RRDT)	2,74	1,88		3,76	2,07			
Post-Test (RRAT)	14,42	1,74	14,79[a]	12,88	2,47	12,46[a]	20,60*	,000

[a]Adjusted Mean; *p<0,05; R Squared= 0,554

The results of ANCOVA showed that the students in the experimental group taught with the laboratory activities exhibited significantly greater acquisition of knowledge of the reaction rate concepts than did those in the control one ($F_{(1; 35)}$= 20,60; p<0.05; Table 2). Responses of the experimental and control group students for each item in the RRDT for are depicted in Figure 2.

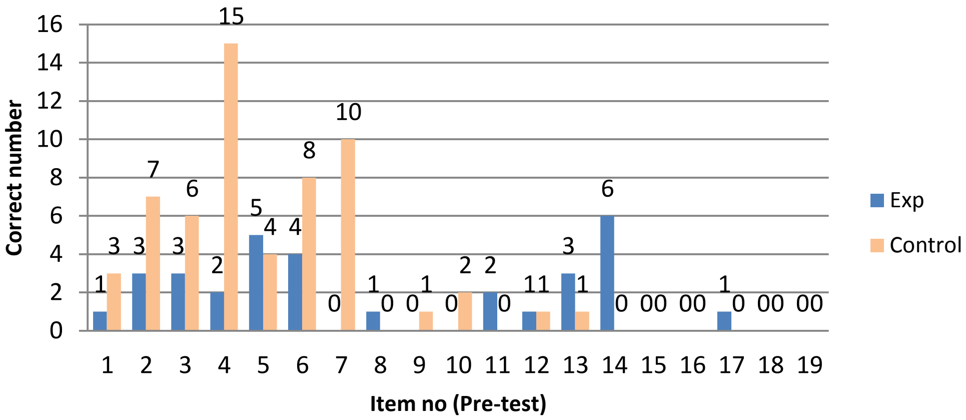

Figure 2. Results of the RRDT for the experimental and control group

As seen in Figure 2, the results from the pre-test shows that the students in both groups have very little knowledge concerning the reaction rate before receiving formal instruction. After the treatment, the RRAT was applied to both groups and its results are depicted in Figure 3. As seen in Figure 3, the experimental and control group students showed progress in increasing their missing and incomplete knowledge the concepts under investigation. However, the progress in experimental group is higher than control group. The findings obtained from the pre- and post-tests showed that the laboratory method is more effective in promoting students' understanding of the reaction rate than the traditional one.

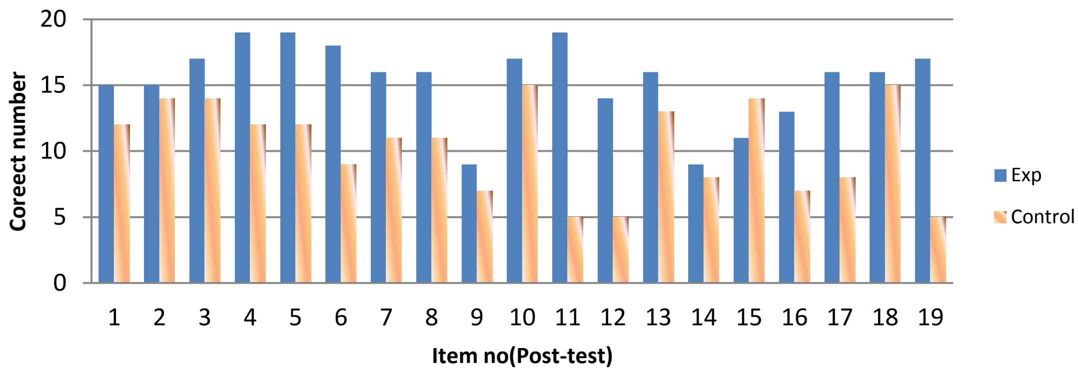

Figure 3. Results of the post-test for the experimental and control group

This was not amazing because the experimental group students were more active in the laboratory setting than in the classroom setting. Also, they had a lot of experience in measuring, interpreting, drawing conclusions, and making generalizations. The findings of this study are in agreement with other studies in the science literature using laboratory method (Hilosky et al.,1998; Odubunni and Balagun, 1991; Tezcan and Bilgin, 2004; Kozcu, 2006; Demircioğlu, 2003; Özmen et al., 2009). Tezcan and Bilgin (2004) found that laboratory method had great contribution to learn the solubility subject and to eliminate the mistakes, wrong ideas, etc. Kozcu (2006) suggested that laboratory method has a much greater effect on students' academic success, level of memory and their sensibility than the traditional one.

CONCLUSION AND SUGGESTION

In this study, it has been tried to evaluate the effect of laboratory method on students' understanding and erroneous ideas about the rate of chemical reactions and laboratory method has much more great effects than the traditional method. The findings indicated that laboratory method can enhance more students' understanding of the reaction rate than the traditional teaching. The study also provides further evidence that the student-centered approaches are more effective in dispelling students' erroneous ideas and improving their understanding than teacher-centered approaches. Both experimental group and control group improved their understanding about the concepts under investigation. But, the growth was higher in experimental group.

The teacher should be encouraged to use the experiments in chemistry textbooks recommended by the Ministry of Education. Number of these experiments and chemistry classes should be increased. The students should perform these experiments themselves rather than demonstrations. Most of the students have *incomplete* and *erroneous ideas* about the rate of reaction and the factors that affect it. So, teachers identify and examine incomplete and erroneous ideas and take them into consideration before formal chemistry instruction.

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