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Investigating the effects of argumentation, problem and laboratory based instruction approaches on pre-service teachers’ achievement concerning the concept of “acid and base”

Cengiz Tuysuz *, Ozan Emre Demirel, Bilal Yıldırım

Education Faculty, Mustafa Kemal University, Hatay, 31100, Turkey

Abstract

Herein, we examine the effect of argumentation, problem, and laboratory based instruction methods on acid and base concept. This study has been carried out with 228 pre-service teachers. The participants were divided into three different experiment groups. Each experiment group was based on argumentation, problem or laboratory. The results of this work indicated that the argumentation-based learning method has advantages over its counterpart methods, although the laboratory-based learning method is more effective in comparison to the problem-based learning method.

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Keywords: Argumentation based instruction; problem based instruction; laboratory based instruction; chemistry; achievement.

1. Introduction

In the last decade, educational policies have been focused on raising individuals who can meet the needs within the field of science and technology (Tatar, 2007). Nowadays, globalization and the increase in working standards and expectations which require knowledge and analytical thinking, the growth in usage of information technologies and the necessity for team work in the business world, have broadened the boundaries of the skills required for working efficiently and professionally. At the present, it is intended to raise expert individuals with strong social awareness and skills, who are able to cooperate and communicate well and who can select, question, collect and use information rather than individuals who only know how to do what they are told (Atasoy, 2004). For this reason, the aim should be to contribute to society’s development by raising constructive and creative individuals, enabling them to acquire the knowledge and skills in conformity with the requirements of our age. Their scientific thinking competences should be developed by directing them with the use of current learning strategies and activities. With these purposes in mind, it is becoming more widespread to utilize student-oriented methodologies such as argumentation, problem and laboratory-based instruction in education to achieve more successful and effective teaching and ultimately learning in chemistry classes (Kayalı, Ürek, & Tarhan, 2002).

Today, it is considered to be of more importance for individuals to constantly evaluate dynamic information, data and possibilities with a questioning and critical approach to make more effective and productive decisions rather than simply retaining knowledge (Tümay & Köseoğlu, 2011). Recently, it has been emphasized in many studies that students should “live” science as argumentation in order to understand scientific thinking (Erduran & Jimenez-
Aleixandre, 2007; Kösöoğlu, Tümay, & Budak, 2008). Argumentation can be described as a process of validating arguments by supporting them with data and providing the appropriate explanations (Toulmin, 1958). Students question the models they have in their minds; they observe the models of their peers and use supportive justification, reason and proof in accordance with the scientific method in order to argue their models with the help of argumentation based instruction. Consequently, conceptual change occurs as a result of debating present models and refuting unacceptable models (Aslan, 2010).

Problem Based Learning (PBL) is a method that enables students to first investigate real work problems on their own before seeking direct knowledge from teachers and text books (Sönmez & Lee, 2003). Complex and real world problems are used for motivating students to research and define the concepts and principles that they should practice in this learning approach (Allen & Duch, 1998). After the students received the problem status, in PBL learning process begins right behind it. In PBL, the learning process begins after giving students the problem. Thus, the students work in parallel with the target information while trying to solve the problem. They learn effectively on their own and also the importance of why they are learning the material. First, they determine the problem status just as in a study conducted by a scientist. Subsequently, the necessary information to solve the problem is collected. Finally, this information is evaluated to obtain a solution for the proposed problem (Çenocak & Taşkesenligil, 2005).

Experimental approaches are largely used to explain the relations between natural incidences and the laws concerning these incidences in scientific instruction (Demir, Böyük, & Koç, 2011). In this manner, students may acquire such skills as developing psychomotor behaviors, interpreting what they see, problem solving, and gaining scientific process skills (Çepni et al., 2005). Beach and Stone (1988) reported that the most efficient way of teaching science was in the laboratory and they added that chemistry instruction without the laboratory was like trying to teach painting without paints and a canvas, or learning how to ride a bike by reading the user’s manual. Lagowski (1989) declared that the laboratory was essential for good chemistry instruction. Demirci (1993) reported that the highest achievement can be reached with laboratory-based learning; however, this can only be possible with teachers who have knowledge on the subject. In an early study, Odubunni and Balagun (1991) found that students who learned by conducting laboratory tests were more successful than those who did not conduct such kinds of tests.

Herein, we study the effects of argumentation, problem and laboratory based instruction methods by applying them to pre-service teachers in chemistry course.

2. Method

2.1. Sample

Results of the studies conducted in science education indicate that the application of new methods and techniques can only be possible by changing teachers’ perceptions and with the use of appropriate instruction applications. For this reason, the importance of the teacher’s education in science education is emphasized in many studies (Driver, Newton & Osborne, 2000; Erduran & Jimenez-Aleixandre, 2007). For that reason, this study has been carried out with 179 pre-service teachers who studied at the Mustafa Kemal University, Faculty of Education, Primary Education Department during the 2011-2012 academic year.

2.2. Data collection instrument

Acid-Base Concept Test (ABCT) was implemented as a pre-test to determine the pre-service teachers’ level of readiness for the acid-base concept and to determine whether there is a difference between the groups in terms of the level of readiness. At the end of the application, ABCT was applied as a post-test to determine if there is a statistically significant difference in the achievement of pre-service teachers in the chemistry course in relation to the results of the methods implemented. ABCT was developed by Tekelleli (2009) as a multiple choice test with 20 questions and 5 choices. The KR-20 reliability coefficient was calculated as 0.86.

2.3. Application
A pre-test and post-test unequalized comparison group model, a quasi-experimental design, was used in the study. Students were divided into three different experimental groups with 5-6 members each according to their mid-term grades in their general chemistry course. ABCT was applied to all of the groups as a pre-test before the application and as a post-test after the application. During the application, the lessons were conducted using an argument-, problem- laboratory-based learning model for first, second and third experimental groups, respectively. The details will be explained below.

Toulmin (1958) expressed his view that argumentation is an inseparable part of the reasoning process in both everyday life and science. In addition, he added that the basic components of argument are claim, data and reason; however, more complex arguments may additionally include support, qualifier and nugatory (Tümay & Köseoğlu, 2011). In this study, the argumentation-based materials that were developed by Tekelli (2009) by taking into account components proposed by Toulmin, were used in the group where argumentation-based learning is realized. During the process, pre-service teachers were enabled to participate in such scientific applications such as creating theories and justification, proposing alternative theories, presenting opposite arguments and refuting. The researcher had the task of including students in the research process and summing up the subject during lessons.

Massa (2008) determined four main steps in the problem-based learning method, which are problem analysis, learning by self-direction, brain storming, and testing the solution. With these parameters in mind, students are presented with the problem, they devise a plan, determine what they know and what they need to know, list possible study strategies, collect information, analyze the data, present the solution and share their findings (Koçakoğlu, 2010). The problem based learning method was applied accordingly in this study. Six problem scenarios developed by Özeken (2011) were used in the group where the problem-based learning methods applied. A seminar introducing the problem based learning method was distributed to the students before the application and the application was realized with a sample problem scenario.

Köse (2008) divided the experiments into three groups according to their purpose as follows: close-ended, open-ended and hypothesis experiments. In this study, hypothesis experiments were used. Therefore, eight experiments were determined by considering the acquirements in the “Acid and Base” unit in the groups where the laboratory-based learning method was applied and these experiments were used in the application.

The present study was performed by using the “Acid and Base” unit in the general chemistry lesson, which is part of the curriculum at the Primary Education Department and it was conducted over 14 lesson hours in all groups.

3. Findings and comments

At the beginning of the study, variance analyses were made to determine whether or not there is a statistical difference between the preliminary knowledge of the three groups where three different methods were applied concerning the “Acid and Base” unit in the general chemistry course. The results are presented in Table 1.

<table>
<thead>
<tr>
<th></th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>2</td>
<td>15,926</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within Groups</td>
<td>226</td>
<td>11,152</td>
<td>1,428</td>
<td>.242*</td>
</tr>
<tr>
<td>Total</td>
<td>228</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

As seen in Table 1, there is no statistically significant difference between the means of the pre-ABCT grades of groups before the application F(1.428)=0.242; P>0.05). Covariance analysis (ANCOVA) was applied to determine if there was significant difference between the post-tests of students in the three groups based on the applied methods. First, the assumptions of this analysis were controlled to figure out whether ANCOVA analysis is an appropriate route for the data obtained. According to Weinfurt (1995), there should be a significant relation between covariates and dependent variables to be able to use a variable as a covariate. Based on this proposal, the Pearson correlation analysis, which was made to determine if a significant relation between pre-tests and post-tests,
confirmed that there is a statistically significant relation between the pre-ABCT and the post-ABCT \( (r=+0.237, n=229) \).

According to Weinfurt (1995), similar dependent variables for each group are important premises of covariate variance analysis. The statistical insignificance of p values is the indicator of the fact that the dependent variables are homogeneous in both groups \( (F=2,984, p=0,530, p<.05) \).

ANCOVA analysis was used to determine the effect of the applied methods on the students’ comprehension of the “Acid and Base” unit when the grades that the students obtained from pre-tests are used as a covariate. The results of this analysis are presented in Table 2.

### Table 2. Covariate Analysis (ANCOVA) Results

<table>
<thead>
<tr>
<th>Source</th>
<th>Variable</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>P</th>
<th>( \eta^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-ABCT</td>
<td>Post-ABCT</td>
<td>1</td>
<td>69,392</td>
<td>6,497</td>
<td>0,011</td>
<td>0,028</td>
</tr>
<tr>
<td>Group</td>
<td>Post-ABCT</td>
<td>2</td>
<td>209,524</td>
<td>19,618</td>
<td>0,000</td>
<td>0,149</td>
</tr>
</tbody>
</table>

As seen from Table 2, there is a statistically significant difference between the mean of grades of the respective groups obtained from the concept test in the “Acid and Base” unit based on the methods used in the study. The partial eta-squared \( (\eta^2) \) value, which is 0.149, shows that 14.9% of the change in the dependent variable results from the application. A Tukey test was used to determine in favor of which group the difference between the groups.

### Table 3. post-ABCT Tukey Test Difference Control Results

<table>
<thead>
<tr>
<th>(I) group</th>
<th>(J) group</th>
<th>Mean Difference (I-J)</th>
<th>Std. Error</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argumentation</td>
<td>PBL</td>
<td>3.290</td>
<td>.529</td>
<td>.000*</td>
</tr>
<tr>
<td>Argumentation</td>
<td>Laboratory</td>
<td>2.036</td>
<td>.527</td>
<td>.000*</td>
</tr>
<tr>
<td>Laboratory</td>
<td>PBL</td>
<td>1.255</td>
<td>.533</td>
<td>.038*</td>
</tr>
</tbody>
</table>

\* p < 0.05

The data in Table 3 confirm that there is a statistically significant difference between the means of grade that the students in the argumentation based learning group obtained from post-ABCT and that of the students in the problem based and laboratory based learning group; it was determined that the group where the argumentation based learning method was applied is the most favorable.

Moreover, there is a statistically significant difference between the means of the grades that the students in the argumentation based learning group obtained from the post-ABCT and that of the students in the problem based learning group; the group where the argumentation based learning method was applied is the most favorable option for optimized student performance.

### 4. Conclusion and discussion

In this study, the effect of argumentation, problem and laboratory based learning methods on the pre-service teachers’ achievement in the general chemistry course were investigated. The findings obtained in our study confirmed that the argumentation based learning method enhanced the abilities of the pre-service teachers to perform well in the general chemistry course more than the problem and laboratory based learning methods. The conducted studies indicated that questioning and assessing a plethora of opinions in the argumentation process helps students to learn the concepts more effectively and meaningfully in science (Zohar & Nemet, 2002; Yeşiloğlu, 2007; Özer, 2009; Tekelli, 2011).

Moreover, it was determined that the laboratory based learning method increased the knowledge, capabilities, and effectiveness of the pre-service teachers in general chemistry more than the problem based learning method. In other studies conducted, it was reported that the laboratory based method mainly increased students’ achievement
Laboratory studies allow students to develop their skills in problem solving, planning and the realization of research, as well as to develop their data collecting and data analysis abilities, which allow the students to make interpretations and extrapolations (Garnett, 1995). For the aforementioned reasons, laboratory based learning increases students’ achievement (Odubunni & Balagun, 1991; Aydoğdu, 2000).

It has been supported in many studies that students receive less information through PBL (Scott, 2005; Sifoğlu, 2007; Korucu, 2007; Dobbs, 2008). Banta et al (2000) states that students who receive education with the PBL method learn less than other students as shown from the results of his interview with the students (Uden & Beaumont, 2006). Cassarino (2006) expresses the view that students should have some threshold competency in order to apply the problem based learning. Even though the problem based learning method is theoretically one of the most important application areas of the constructivist approach, some basic conditions should be met and students should be taught the competences required for learning with this method in order to achieve productive results (Koçakoğlu, 2010).

Acknowledgements

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References


