The effect of laboratory activities based on 5e model of constructivist approach on 9th grade students’ understanding of solution chemistry

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Abstract

Solution chemistry plays an important role in students’ understanding of other related abstract chemistry topics such as acids and bases and chemical equilibrium. From this, it was aimed to investigate whether the laboratory activities based on the 5E model of the constructivist approach has a significant effect on academic achievement of 9th grade students. The present study was conducted with a total of 52 9th grade students in a high school located in the province of Trabzon. While 26 of them were randomly assigned to the experimental group, the other was assigned as the control group (26). The same teacher taught both groups. The experimental group students were taught with laboratory activities based on the 5E model of the constructivist approach whereas the students in the control group were taught with the traditional approach. The laboratory activities based on the 5E model were performed during two lesson periods (45-min per lesson). A Chemistry Achievement Test (CAT) consisting of 11 open-ended questions was developed by the authors. It was applied to both groups. The validity of the CAT was examined by a commission involving 3 academicians and 2 chemistry teachers. The data obtained from pre- and post-tests of both groups was compared with the independent t-test. The results from pre-tests showed that there was no significant difference between control group and experimental group. On the other hand, the post-test results showed that there was a significant difference between groups in favor of the experimental group. It is essential that teachers should develop their skills for designing a constructivist-learning environment within class and laboratory activities. With this aim, teachers should be given in-service training.

Keywords: Constructivist approach, 5E model, laboratory activities, solution chemistry;

1. Introduction

According to the constructivist theory of learning, students construct their own understanding on the basis of an interaction between knowledge and views they already hold and information they encounter (Resnick, 1989) and actively participate in the process of meaningful construction. Laboratory activities may make students more active

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in their learning than in a classroom setting. Hart et al. (2000) suggests that students enjoy laboratory activities because of the fact that it is more active. In the laboratory setting, students have a chance to engage in hands-on activities (Markow & Lonning, 1998). The 5E model based on the constructivist theory of learning was developed by the Biological Sciences Curriculum Study and provides an instruction method that constructs students’ own understanding about scientific concepts, encourages them to explore, and relates those ideas to other concepts. In recent years, there has been increasing interest in this model. In our country, there have also been a great number of research studies conducted regarding effect of 5E learning model on students’ understanding of science concepts (Demircioğlu et al., 2004; Yadigaroğlu & Demircioğlu, 2012).

Students of different ages and grade levels in different countries described chemistry as a difficult subject because it has a lot of abstract concepts (Ayas & Demirbaş, 1997) and requires understanding on both macroscopic and microscopic levels. In high school chemistry curricula, solution chemistry and its sub-concepts have an important place in completely understanding other related concepts such as acids and bases, and chemical equilibrium. However, most students have difficulty in understanding of the concepts related to solution chemistry (Pınarbaşı & Canpolat, 2003; Calık, 2005; Blanco & Prieto, 1997). These studies showed that students often held alternative concepts about solution chemistry. These alternative concepts have negative effects on teaching and learning processes (Ebenezer, 2001). For this reason, it is very significant to develop teaching activities taking into consideration students’ preconceptions. In the present study, we investigated the effect of laboratory activities based on the 5E model of constructivist approach on 9th grade students’ understanding of solution chemistry.

2. Method

A non-equivalent control group design, a type of the quasi-experimental research, was used in the present study because participants were not randomly assigned to groups (Cresswell, 1994). 52 9th grade students in a high school located in the province of Trabzon voluntarily participated in the study. While 26 of them were randomly assigned to the experimental group (EG), the other was assigned as the control group (CG). The teacher with 10 years of experience in teaching chemistry taught both groups.

2.1 Data collection tool

The Chemistry Achievement Test (CAT): An eleven-item test consisting of 11 open-ended items was constructed to identify the students’ understanding of solution chemistry and applied to both groups before and after the treatment. After review of literature about solution chemistry, the items in the test were developed by the authors. Two chemistry educators and two experienced chemistry teachers examined the instrument for content validity. Students responses to items were classified into five categories; “understanding”, “partial understanding”, “misconceptions”, “irrelevant answer” and “no answer” (Haidar, 1991). The categories were scored from 0 (no answer) to 4 (sound understanding) and the total score of the test was 44 points.

2.2 The development of the material

The teaching material used in the study was developed by the authors in accordance with the 5E model of the Constructivist theory of learning. To develop the material, we examined a number of related resources such as the Turkish chemistry textbooks, 9th grade chemistry curriculum, and annual plans prepared by chemistry teachers to determine the depth, size and time devoted for teaching the topic.
Enter/Engage
In this stage, the teacher used “brainstorming technique” in order to explore students’ existing conceptions.
“What are the solutions we often use in daily life?” Give examples.
“Is the sea a mixture?”

Explore
In this stage, students performed 4 different experiments.
1. Experiment; 2 bottles of soda, a few ice cubes, some hot water, and a bottle opener, were delivered to the groups and then they were given an experimental procedure explaining the steps. In this section students had to find out if the dissolution of gas in to a liquid changes with temperature or pressure effect.
2 and 3. Experiments; 1g KNO₃, 2g CaCO₃, water, spirit stove, test tube, a few ice cubes, spatula were delivered to groups. They were given a worksheet explaining the steps of the experiment; each group observed the effect of temperature on dissolution rate of a solute and wrote their observations on worksheets. In this section with the KNO₃ experiment; the aim was to overcome misconception about solution classifications, one of the misconceptions was “Saturated solutions are always concentrated and unsaturated solutions are always diluted.” The CaCO₃ experiment engaged students to observe if the dissolution of solid changes with temperature effect.
4. Experiment; Crystallized CuSO₄, powder CuSO₄ and 2 test tubes were given students with experimental procedure. They were expected to observe factors effecting rate of solubility. Each group did the activities, wrote down their observations, and discussed their results to reach a joint decision.

Explain
At this stage, groups shared and discussed the results with the whole class. The teacher helped students connect their explanations to experience they had in the engage and explore stage and gave new examples from daily life.

Elaborate
Students watched a video from daily life related to solubility and its characteristics. The video was about decompression illness (DCI). Students tried to explain the reason of DCI and dissolution of N₂ gas in blood. They also made connection between video, their discussion and experiments as they did in the explore step of 5E.

Evaluate
In this stage, the diagnostic tree technique was used to determine whether or not students learned the concepts related to solubility, gas and solid solutions, characteristics of solubility, and the effect of temperature on solubility.

The topics covered in the material were; properties of solutions, rate of solubility, effect of pressure on solubility, classification of different solutions, and the relationship between solubility and temperature. It required the students’ active participation and two class hours. The control group used the same number of lessons, but was taught with traditional approach. Before the activity, students were divided into the groups of 5-6 students and all necessary materials were given. The stages of the model and teaching practices in each stage are given in Table 1.

3. Results and discussion

Before the treatment, the pre-test scores were evaluated and compared with the independent sample t-test. As seen in Table 2, there was no statistically significant difference between the experimental group and the control group with regard to the achievement. Because there was no difference between the pre-test results, post-test means are also compared with the t-test. After the treatment, post-test scores were evaluated and compared by using independent samples t-test. As seen in Table 2, there was a statistically significant difference between experimental and control group scores (p<0.05). The main aim of the present study was to investigate the effect of laboratory activities based on the 5E model on students’ understanding of solution chemistry. The statistical results showed that constructivist laboratory activities used in the experimental group was more effective on students’ achievement than traditional laboratory activities used in the control group.

Table 2. The results of the t-test on pre- and post-test scores of both group students

<table>
<thead>
<tr>
<th>Tests</th>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>df</th>
<th>S.D</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-test</td>
<td>Experimental</td>
<td>26</td>
<td>18.46</td>
<td>50</td>
<td>3.51</td>
<td>4.36</td>
<td>0.065</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>26</td>
<td>17.90</td>
<td>50</td>
<td>3.80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-test</td>
<td>Experimental</td>
<td>26</td>
<td>32.79</td>
<td>50</td>
<td>4.37</td>
<td>4.17</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>26</td>
<td>27.50</td>
<td>50</td>
<td>4.60</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3 summarizes the data obtained from the pre- and post-tests. In the “understanding” category, while the percentage of students’ responses in EG ranged from 0% to 31% in pre-test, it ranged from 0% to 73% in the post-
test and while the percentage of students’ responses in CG ranged from 0% to 15% in pre-test, it ranged from 0% to 50% in the post-test (see Table 3). In the “Partial Understanding” category, while the percentage of students’ responses in EG ranged from 0% to 50% in pre-test, it ranged from 4% to 85% in the post-test and while the percentage of students’ responses in CG ranged from 0% to 35% in pre-test, it ranged from 8% to 50% in the post-test. The percentage of students’ misconceptions in EG in the pre-test ranged from 0% to 35%, while they ranged from 0% to 38% in the post-test. On the other hand, percentage of students’ misconceptions in CG in the pre-test ranged from 0% to 65%, while they ranged from 0% to 54% in the post-test.

Table 3. The distribution of both group students’ responses on the pre- and post-tests across the organized categories

<table>
<thead>
<tr>
<th>Category</th>
<th>EG Pre</th>
<th>EG Post</th>
<th>CG Pre</th>
<th>CG Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>U</td>
<td>2</td>
<td>8</td>
<td>5</td>
<td>19</td>
</tr>
<tr>
<td>P</td>
<td>1</td>
<td>8</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>M</td>
<td>8</td>
<td>13</td>
<td>31</td>
<td>50</td>
</tr>
<tr>
<td>I</td>
<td>14</td>
<td>54</td>
<td>6</td>
<td>23</td>
</tr>
<tr>
<td>A</td>
<td>14</td>
<td>54</td>
<td>2</td>
<td>8</td>
</tr>
</tbody>
</table>

* U: Understanding;  PU: Partial understanding;  M: Misconception;  IA: Irrelevant answer;  NA: No Answer

4. Conclusion and suggestion

The present study investigated the effect of laboratory activities based on the 5E model of the constructivist approach on 9th grade students’ understanding and misconceptions of solution chemistry. The results showed that students in the EG performed much better in the post-test than the Control group students. This finding indicated that the 5E model of the Constructivist Approach is more effective on students’ understanding and misconceptions than traditional laboratory approach. This result is consistent with the findings from the previous studies on the 5E model (Ebenezer & Erickson, 1996). Although the students in each group increased their achievement scores from...
pre-test to post-test, these gains were not too high. The results of the study also showed that students in both groups had many misconceptions in solution chemistry before and after the treatment. After the treatment, each group showed progress in eliminating their misconceptions, but the experimental group was better overall. Moreover, the activities based on the 5E model here not only increased the success but also enabled students to make relationships between their daily life and the concepts related to solution chemistry. This and similar studies may be considered a small step on a shift from a teacher-centered to a student-centered strategy in Turkish schools. For further work, similar studies can be constructed for other topics or concepts of secondary chemistry education and with larger sample sizes. In addition, curriculum designers and teachers should take these strategies into consideration when developing new science curriculum.

References


