DEVELOPING A LABORATORY ACTIVITY ON ELECTROCHEMICAL CELL BY USING 5E LEARNING MODEL FOR TEACHING AND IMPROVING SCIENCE PROCESS SKILLS

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Abstract
The purpose of this study is to develop a laboratory activity based on 5E learning model enriched with different conceptual change methods such as computer animations, conceptual change text, worksheet and hands-on activities for eliminating prospective science teachers' (PSTs) misconceptions of 'electrochemical cells' and improving their SPS. A group of experts was asked to comment on the laboratory activity. The pilot study of the laboratory activity was carried out with 48 third year PSTs enrolled in ‘Science Laboratory’ course in the academic year of 2010-2011 at the Faculty of Education, Giresun University, Turkey. In this paper, all phases of the activity are introduced in detailed. Also, the effect of activity was investigated in a pilot study, based on observation by an independent researcher. In-class observations showed that the activity is effective to improve the students’ motivation and enables them to be active during the learning process. To investigate this and other similar activities’ applicability in a comparative manner, further research should be undertaken. In addition, the effect of the laboratory activity based on 5E learning model combining different conceptual change methods should be examined if it helps the PSTs overcome their misconceptions and improve their SPS.

Keywords: Pre-service Teacher Education, 5e Learning Model, Science Process Skills, Laboratory Activity, Electrochemical Cell.

INTRODUCTION

Which one is more important: Giving the scientific content to the students or Science Process Skills (SPS) in science education? Both scientific content and SPS have the same importance in Science Education. When the literature is investigated, it is observed that there has been a positive relationship between students’ conceptual development and SPS (e.g. Beaumont Walters & Soyibo, 2001; Wilke & Straits, 2006).

In order to succeed conceptual teaching effectively and gain SPS, the students first need to teach the ways of reaching knowledge. SPS is highly important in teaching ways of reaching knowledge...
(Ayas et al., 1997; Laugksch, 2000). Besides, to provide a lasting learning is important that achieve conceptual change together with removing their misconceptions. However, when the studies conducted around the world are investigated, it was determined that the students have some misconceptions before or after they come to the classroom. These misconceptions will affect students’ future learning negatively as clearly indicated in the literature (Ayas et al., 2010; Niaz et al., 2002; Canpolat et al., 2006). In this respect, it is also important that the students need to get rid of misconceptions. Term ‘misconceptions’ means that students hold various conceptions which differ from the scientific one accepted by scientific community (e.g. Cho, Kahle, & Nordland, 1985; Bodner, 1986, Çalık & Ayas, 2005). They may result from instruction, or teachers, or the textbooks or the discrepancy between daily language and scientific language or students’ social environments (e.g. Hand & Treagust, 1991; Nakleh, 1992). This means that teachers are potentially one of resources producing misconceptions. Phrased differently, if teachers or student teachers do not fully hold sophisticated subject matter knowledge and think their existing conceptions are correct, they may engender students’ misconceptions (e.g. Ginns & Watters, 1995; Çalık & Ayas, 2005). For this reason, remedying student teachers’ misconceptions would be worthwhile to prevent teacher-based misconceptions. In the related literature, it is expressed that laboratory activities prepared based on concept teaching and SPS help students’ conceptual development (Nicosia et al., 1984; Dawson, 1999; Beaumont Walters and Soyibo, 2001; Kanlı, 2007, Karslı, 2011). In this context, laboratory activities offering the opportunity on both improving SPS and conceptual change of prospective science teachers are essential and important.

Chemistry has been described as a difficult school subject by students of different ages in different countries, because it has a lot of abstract concepts (Orgill & Bodner, 2004; Ayas & Demirbaş, 1997; Nakleh, 1992). As well as, it was determined that “electrochemistry” was the most difficult topic to teach and understand for teachers, student teachers and students because of its complex structure (Ogude & Bradly, 1996, Finley, Stewart, & Yarroch, 1982; Butt & Smith, 1987). There are several studies conducted to determine misconceptions about electrochemistry in the literature (e.g. Schmidt, Marohn & Harrison, 2007; Yılmaz, Erdem & Morgil, 2002; Sanger and Greenbowe, 1997; Garnett & Treagust, 1992). If students describe a topic as challenging and if they have misconceptions about that topic that affects their performance for future learning. Just because of this, it is a need in teaching to focus on the topics which are difficult. There should be undertaken studies to find out learning obstacles and then to overcome these. Student-centered learning environments which are enriched by effective methods and techniques are needed in order to help the students understand the challenging concepts. Some studies have suggested ways of remedying misconceptions about electrochemistry in the literature. These studies have used one conceptual change method and/or technique such as computer animations (Doymus, Karacop & Simsek, 2010; Sanger & Greenbowe, 2000; Yang, Andre & Greenbowe, 2003) or computer-assisted learning (Talib, Matthews & Secombe, 2005), conceptual change instruction (e.g. Huddle, White & Rogers, 2000; Sanger & Greenbowe, 2000), cooperative learning strategies (Acar & Tarhan, 2007), conceptual change text (Yürük, 2007) and jigsaw puzzle techniques (Doymus et al., 2010). All of
them point out that their conceptual change methods and/or techniques are effective in remedying students’ misconceptions. But they also report that the techniques they used fail to completely overcome the students’ misconceptions in electrochemistry. In fact, this may stem from structure of conceptual change method and/or technique they used. That is, using just one teaching method to accomplish conceptual change may in fact result in some disadvantages (e.g. Karsli & Calik, 2012; Şahin, Çalık & Çepni, 2009). For example, students soon become bored with continued reading of conceptual change texts or use of computer animation or analogy (e.g. Çalık, Ayas & Ebenezer, 2009; Orgill & Bodner, 2004). To prevent such problems, using two or more conceptual change methods or techniques may help students develop a better conceptual understanding because this process gives an opportunity for students to expose to an enriched learning environment.

**Theoretical Framework**

SPS defined as the adaptation of the skills used by scientists for composing knowledge, thinking of problems and making conclusions. SPS are also defined as facilitating basic activities as regards learning science, gaining research method and techniques, helping students to be active and to make learning permanent. SPS are classified as basic (observation, testing, classification, relating number with space, and recording data,), causal (prediction, determination of variables, and drawing a conclusion), and experimental (making a hypothesis, modeling, doing the experiment, changing and testing the variables, and making a decision) (Ayas et al., 2007). In the new curriculum of science and technology developed by Ministry of National Education, it is emphasized on developing students’ SPS (MNE, 2006).

When the Science programs are investigated, most of the countries including Turkey use 5E learning model as a main. 5E learning model that is a quite popular version of constructivism (e.g. Hırça, Çalık & Seven, 2011) and has more effect to develop students’ SPS (e.g. Padilla et al., 1984; Aktamış & Ergin, 2007). This model was used in this study because it enables variety in teaching and it provided opportunities for the rich learning environments to be organized. Since each “E” represents part of the process of assisting students’ learning sequence and experiences in linking prior knowledge with new concepts, this model comprises of: engagement, exploration, explanation, elaboration, and evaluation (e.g. Abell & Volkman, 2006). In this study, 5E learning model was incorporated in different conceptual change methods such as animations, conceptual change texts and hands-on activities.

Animations which offer various opportunities to the educational environment are described as the motion of many pictures and figures in a scenario. We here preferred the use of animations for several reasons (i) to make abstract concepts or phenomena ‘concrete’, (ii) to promote individual learning, (iii) to provide a better student engagement with the learning of science.
Conceptual change texts are one of the other concept teaching strategies and help the students by eliminating their alternative concepts and make the students understand. The authors here selected the use of conceptual change texts because of its economy, time-efficiency and ease of use. Work sheet is the document which includes instructions related to the activities for the students to follow while teaching a topic. Since the worksheet is seen as a class task organizer, they increase positively the student attitudes towards chemistry education (e.g. Coștu & Ünal, 2004). Thereby, the authors here preferred use of worksheet due to its time-efficiency and class task organizer.

The purpose of this study is to develop a laboratory activity based on 5E learning model enriched with different conceptual change methods such as computer animations, conceptual change text, worksheet and hands-on activities for eliminating PSTs misconceptions of ‘electrochemical cells’ and improving their SPS.

**METHOD**

This research is a study based on developing and using a laboratory activity. To develop this activity, firstly misconceptions in electrochemistry have been determined from the related literature. In this activity, focused misconceptions are: “placement and negative or positive charge of the anode and cathode”, “the direction of electron flow”, “the direction of ions flow on the salt bridge”, “writing the cell reaction” and “anode and cathode electrodes’ mass”. After determining the misconceptions, which SPS could be gained from the activity were confirmed as a second stage. A draft of the a laboratory activity based on 5E learning model enriched with different conceptual change methods such as computer animations, conceptual change text, worksheet and hands-on activities both eliminating PSTs’ misconceptions of ‘electrochemical cells’ and improving their SPS was then prepared. A group of experts was asked to comment on the laboratory activity. According to the views of experts, the activity was revised. The activity was later implemented as a pilot study. To test the effect of activity, an independent researcher participated in intervention and observed how the students reacted. Further, the worksheets were examined.

**Pilot Study:**

A pilot study was carried out with 48 third year PSTs (24+24, two classes) enrolled in ‘Science Laboratory’ course in the academic year of 2010-2011 at the Faculty of Education, Giresun University, Turkey. Seven groups, consisting of 4 PST were formed in each class. The worksheets based on 5E learning model enriched with different conceptual change methods were handed out to each PST. The pilot study took 90 minutes.

**Teaching Design**

Because we prefer the 5E learning model, now we will present what-how to embed the conceptual change methods and/or techniques within 5E learning model in worksheet.
Engagement/Enter (5 or 10 minutes):

Luigi Galvani character was used to capture students’ attention saying “Did you know that I discovered the working principle of the cells that you use by starting with the event of the contraction of a dead frog’s leg?” The students were asked the questions in the first stage of the worksheet to increase students’ awareness of electrochemical cells concept and activate their pre-existing ideas and come to their attention to subject. At the same time the students were asked designing an experiment, determination of variables and making hypothesis about the electrochemical cells. They are asked to write their answers down to the worksheet. The instructor provided just an atmosphere for discussion and did not give any answer about these questions. It is presented the engagement phase of the worksheet below (Fig. 1).

Exploration (25 or 30 minutes):

The instructor played a leading role in following the steps in work sheet by making the students work together and giving them opportunities to communicate with each other in the prepared laboratory environment in this step. The instructor enabled the experimental set up to be set. After each group respectively had stated the potential difference values that were read in galvanic cell which was set up and their observations, the students were asked to fill in the gaps given in work
sheet tables. The students were asked why the values that were read were different. What the required conditions were for the formation of a battery cell were discussed. This phase gives opportunities students to gain SPS as observing, measuring, classifying, data recording, graphing, interpreting the data, drawing conclusion, experimenting.

Explanation (30 or 35 minutes):

The instructor handed out conceptual change text (CCT). The students read CCT and discussed each misconception and their reasons. In this phase, the students were given opportunities to realize misconceptions and change them with the new ones. At this point, the instructor explained related scientific concepts, i.e. anode, cathode, function of salt bridge, conversion from chemical energy into electrical energy, galvanic cell, electromotor power of the cell (cell potential) and so forth. For this, the instructor used CCT developed by authors and computer Animation 1 retrieved from (URL-1, 2010) and adapted to Turkish in order to explain in detail how electrical energy was produced from chemical energy.

![Image](fig2.png)

**Fig 2. A sample screen from Animation 1**

Elaboration (15 or 20 minutes):

Three questions in worksheet were asked to the students and their answers were received in this step. The students watched computer Animation 2 retrieved from (URL-1, 2010) in order to be shown the more detailed working principle of dry cells which were used in daily life. It was explained that ‘While a dentist was filling a tooth, a galvanic cell, in other terms a battery cell, was formed in the patient’s mouth. The dentists use gold or silver as cement. The steel forceps or probes make up a battery cell when interacted with the cement. The metal probe acts like an electrode and the cement acts like another electrode. The saliva secretion functions as an electrolyte solution. The electrical energy which was produced in small quantity stimulates the nerves in the tooth and causes a small pain’. These explanation provided students to find answers to the questions which were asked in the engagement /entry step and express their ideas. In addition, it
was emphasized that how and in what way the concepts mentioned in the school or laboratory appeared in our daily life.

**Evaluation (10 minutes):**

The instructor asked students to transfer their newly structured knowledge to different questions last part of the worksheet. To evaluate students’ conceptual understanding about electrochemical cells, the instructor used branched diagnostic tree. The instructor evaluated her students’ abilities and extended knowledge. Some of the questions used in this phase: “What is the net cell reaction?”, “What are half-cell reactions occurring at the cathode and anode electrodes?”, “Please draw the battery cell schema” and so forth.

**CONCLUSION**

In this study, a laboratory activity based on 5E learning model combining different conceptual change methods is illustrated here. In-class observations made in pilot study showed that the laboratory activity is effective to improve the students’ motivation and enables them to be active during the learning process. However, the study has some limitations in providing concrete evidence, because this is not an experimental study. For this reason, to investigate its applicability in a comparative manner, further research should be undertaken. In addition, the effect of the laboratory activity based on 5E learning model combining different conceptual change methods should be examine if it helps the PSTs overcome their misconceptions and improve their SPS.

*Note:* Because of page limitation, teaching materials have not been presented here, but the audience or researchers may directly supply them from the authors.

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