WESTERN ANATOLIA JOURNAL OF EDUCATIONAL SCIENCE

http://web.deu.edu.tr/baed
Dokuz Eylul University Institute of Educational Sciences

ISSN 1308 – 8971

Special Issue: Selected papers presented at WCNTSE

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

[a]Fethiye KARSLI & [b]Alipaşa AYAS

[a] Res. Ass., Giresun University, Department of Primary Teacher Education, Giresun, Turkey, fethiyekarsli28@gmail.com
[b]Prof. Dr., Bilkent University, Faculty of Education, Ankara, Turkey, alipasaayas@yahoo.com

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; Nakhleh, 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; Nakhleh, 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. Coştu & 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:

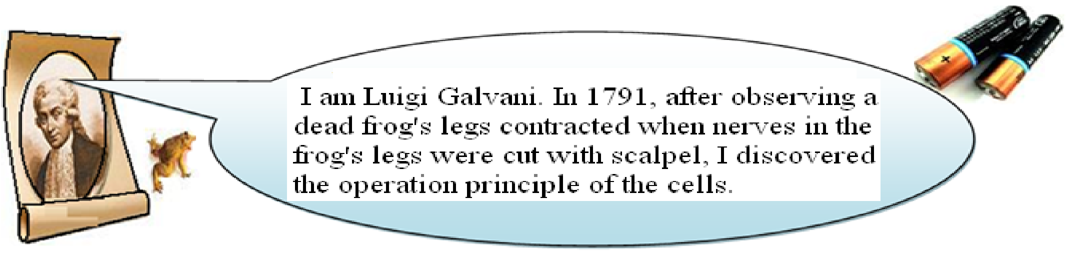
A pilot study was carried out with 48 third year PSTs (24+24, two classes) enrolled in 'Science Laboratory' course in the academic year of 2010-2011 at the Faculty of Education, Giresun University, Turkey. Seven groups, consisting of 4 PST were formed in each class. The worksheets based on 5E learning 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).



a) What do you think about relationship between Galvanic cells and the dead frog's leg?
b) Why is this process called 'electrochemistry'?
c) How do these cells in mobile phones, MP3 players, laptops and remote controllers produce necessary energy to operate them?

You will find an answer after completing the following activities. For this reason, taking the direction into consideration, please respond the given questions.

Please design an experiment about conversion from chemical energy to electrical energy using the following materials.

Materials and Equipment Used:
Beaker, conducting wire, cables with alligator clips, U-tube, glass cotton, voltmeter, metal electrodes made of Cu, Zn, 0,5 M Zinc Sulfate ($ZnSO_4$), 0,5 M Copper Nitrate ($Cu(NO_3)_2$), saturated KCl solution.

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

Please fill in the following spaces based on your designed experiment.

Please write your the experiment' hypothesis.
Hypothesis:
Identify variables of the experiment.
Dependent variables:
Independent variables:
Controlled variables:

Fig 1. A part of the worksheet

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.

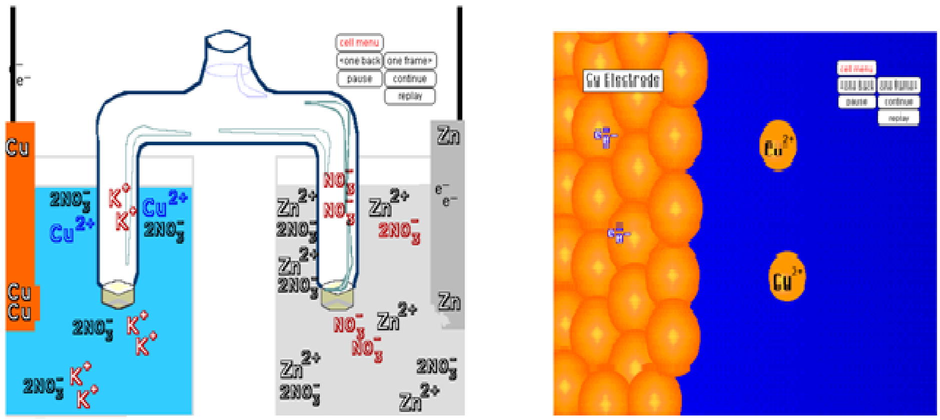


Fig 2. A sample screen from Animation 1

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.

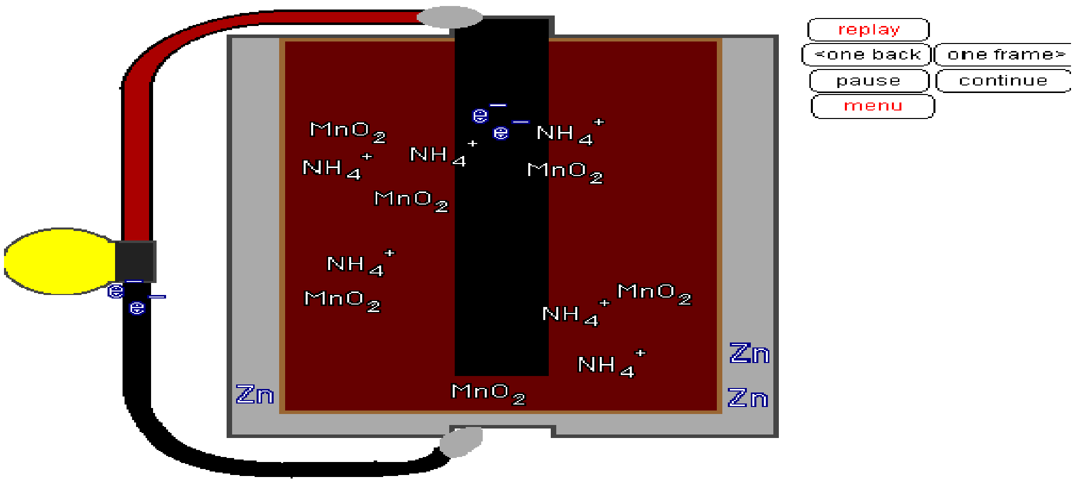


Fig 3. A sample screen from Animation 2

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.

Acknowledgement

This study was supported by Research Fund of Karadeniz Technical University, Project Number: 2009.116.002.1

REFERENCES

Abell, S. K., & Volkmann, M. J. (2006). *Seamless assessment in science: A guide for elementary and middle school teachers.* Portsmouth, NH: Heinemann.

Acar, B., & Tarhan, L. (2007). Effect of cooperative learning strategies on students' understanding of concepts in electrochemistry. *International Journal of Science and Mathematics Education*, 5, 349-373.

Aktamış, H. & Ergin, Ö. (2007). Investigating the relationship between science process skills and scientific creativity. *Hacettepe University Journal of Education*, *33,* 11-23.

Ayas, A., & Demirbaş, A. (1997). Turkish secondary students' conception of introductory chemistry concepts. *Journal of Chemical Education*, 74(5), 518-521.

Ayas, A., Çepni, S., Johnson, D., & Turgut, M., F. (1997). *Kimya Öğretimi, Öğretmen Eğitimi Dizisi, YÖK/Dünya Bankası,* Milli Eğitimi Geliştirme Projesi Yayınları, Bilkent, Ankara.

Ayas, A., Çepni, S., Akdeniz, A., Özmen, H., Yiğit, N., & Ayvacı, H. Ş. (2007). *Science and Technology Teaching From Theory to Application*. PegemA Yayıncılık, 6. Baskı, Ankara.

Ayas, A., Özmen, H., & Çalık, M. (2010). Students' Conceptions of the Particulate Nature of Matter at Secondary and Tertiary Level. *International Journal of Science and Mathematics Education*, 8, 1, 165-184.

Beaumont Walters, Y., & Soyibo, K. (2001). An analysis of high school students' performance on five integrated science process skills. *Journal of Research in Science & Technological Education, 19, 2.*

Bodner, G. (1986). Constructivism: A theory of knowledge. *Journal of Chemical Education*, 63, 873–878.

Butts, B., & Smith, R. (1987). what do students perceive as difficult in HSC chemistry? *Australian Science Teachers Journal*, 32(4), 45-51.

Canpolat, N., Pinarbasi, T., & Sozbilir, M. (2006). Prospective Teachers' Misconceptions of Vaporization and Vapor Pressure. *Journal of Chemical Education*, 83, 8, 1237-1242.

Çalık, M., & Ayas, A. (2005). A comparison of level of understanding of grade 8 students and science student teachers related to selected chemistry concepts. *Journal of Research in Science Teaching*, 42(6), 638-667.

Çalık, M., Ayas, A., & Ebenezer, J. V. (2009). Analogical reasoning for understanding solution rates: Students' conceptual change and chemical explanations. *Research in Science & Technological Education*, 27(3), 283-308.

Cho, H., Kahle, J. B., & Nordland, F. H. (1985). An investigation of high school textbooks as source of misconceptions and difficulties in genetics and some suggestions for teaching genetics. *Science Education*, 69, 707-719.

Coştu, B., & Ünal, S. (2004**).** The use of worksheets in teaching Le-Chatelier's principle. *Yüzüncü Yıl University, Journal of Education Faculty, 1*(1) Retrieved May 13, 2005 from http://efdergi.yyu.edu.tr/makaleler/cilt_I/bayram_suat.doc.

Doymus, K., Karacop, A., & Simsek, U. (2010). Effects of jigsaw and animation techniques on students' understanding of concepts and subjects in electrochemistry. *Education Tech Research Dev*, published online first at http://www.springerlink.com/content/124h325536840r45/fulltext.pdf.

Dawson, C. C. (1999). The Effect of Explicit Instruction in Science Process Skills on Conceptual Change: A Case Study of Photosynthesis, PhD Thesis, University of Northern Colorado.

Finley, F. N., Stewart, J., & Yarroch, W. L. (1982). Teachers' perceptions of important and difficult science content. *Science Education*, 66, 531–538.

Garnett, P. L., & Treagust D. F. (1992). Conceptual difficulties by senior high school students of electrochemistry: Electric circuits and oxidation-reduction equations. *Journal of Research in Science Teaching*, 29(2), 121-142.

Ginns, I. S., & Watters, J. J. (1995). An analysis of scientific understandings of preservice elementary teacher education students. *Journal of Research in Science Teaching*, 32(2), 205-222.

Hand, B., & Treagust, D. F. (1991). Student achievement and science curriculum development using a constructive framework. *School Science and Mathematics*, 91, 172–176.

Hırça, N., Çalık, M., & Seven, S. (2011). Effects of guide materials based on 5E model on students' conceptual change and their attitudes towards physics: A case for 'work, power and energy' unit. *Journal of Turkish Science Education*, 8(1), 153-158.

Huddle, P. A., White, M. D., & Rogers, F. (2000). Using a teaching model to correct known misconceptions in electrochemistry. *Journal of Chemical Education*, 77(1), 104-110.

Kanlı, U. (2007). The effects of a laboratory based on the 7e model wıth verification laboratory approach on students' development of science process skills and conceptual achievement. Ph. D. Thesis. Gazi University, Ankara.

Karslı, F. (2011). The Effect of Enriched Laboratory Guide Materials on Improving Science Process Skills and Conceptual Change of Prospective Science Teachers. Ph. D. Thesis. Gazi University, Ankara.

Karsli, F. & Calik, M. (2012). Can Freshman Science Student Teachers' Alternative Conceptions of "Elekctrochemical Cells" Be Fully Diminished? *Asian Journal of Chemistry*, 24 (2), 485-491.

Laugksch, C. R., 2000. Scientific Literacy: A Conceptual Overview. *Science Education*, 84, 1, 71-94.

Ministry of National Education, *Science and Technology Teaching Program (Elementary Education 6, 7, and 8th grades.* Ankara. (2006).

Nakhleh, M. B. (1992). Why some students don't learn chemistry. *Journal of Chemical Education*, 69(3), 191-196.

Niaz, M., Aguilera, D., Maza, A., & Liendo, G. (2002). Arguments, Contradictions, Resistances, and Conceptual Change in Students' Understanding of Atomic Structure. *Science Education*, 86, 505-525.

Nicosia, A., M., L., Mineo, S. R. M., & Valenza, M., A. (1984). The Relationship Between Science Process Abilities of Teachers and Science Achievement of Students: An Experimental Study. *Journal of Research in Science Teaching*, 21, 853-858.

Ogude, A. N., & Bradly, J. D. (1996). Electrode processes and aspects relating to cell EMF, current, and cell components in operating electrochemical cells. *Journal of chemical Education*, 73, 1145-1149.

Orgill, M., & Bodner, G. (2004). Contributions of educational research to the practice of chemistry education methods and issues of teaching and learning. *Chemistry Education: Research and Practice*, 5(1), 15-32.

Padilla J. M., Okey, J. R & Garrard, K. (1984). The Effects of Instruction on Integrated Science Process Skill Achievement. Journal of Research in Science Teaching. 21 (3) 277-287.

Şahin, Ç., Çalık, M., & Çepni, S. (2009). Using different conceptual change methods embedded within 5e model: A sample teaching of liquid pressure. *Energy Education Science and Technology Part B: Social and Educational Studies,* 1(3), 115-125.

Sanger, M. J., & Greenbowe, T. J. (1997). Students' misconceptions in electrochemistry: Current flow in electro1ytc solutions and the salt bridge. *Journal_ of Chemical Education*, 7(74), 819-823.

Sanger, M. J., & Greenbowe, T. J. (2000). Addressing student misconceptions concerning electron flow in aqueous solutions with instruction including computer animations and conceptual change strategies. *International Journal of Science Education*, 22(5), 521-537.

Schmidt, H. J., Marohn, A., & Harrison, A. G. (2007). Factors that prevent learning in electrochemistry. *Journal of Research in Science Teaching*, 44(2), 258–283.

Talib, O., Matthews, R., & Secombe, M. (2005). Computer-animated instruction and students' conceptual change in electrochemistry: Preliminary qualitative analysis. *International Education Journal*, 5(5), 29–42.

Wilke, R. R., & Straits, W. J. (2006). Developing students' process skills in today's science classroom. *The Texas Science Teacher,* 11-16.

Yang, E., Andre, T., & Greenbowe, T. (2003). Spatial ability and the impact of visualization/animation on learning electrochemistry. *Journal of Science Education*, 25(3), 329-349.

Yılmaz, A., Erdem, E., & Morgil, İ. (2002). Students' misconceptions concerning electrochemistry. *Hacettepe University Journal of Education*, 23, 234-242.

Yürük, N. (2007). The effect of supplementing instruction with conceptual change texts on students' conceptions of electrochemical cells. *Journal of Science Technology*, 16, 515–523.

URL-1, http://www.scribd.com/doc/19764695/simulation-electrochemistry Retrieved September 1, 2010.