Interactive multimedia module in the learning of electrochemistry: effects on students’ understanding and motivation

Tien Tien Lee\textsuperscript{a*}, Kamisah Osman\textsuperscript{b}

\textsuperscript{a}Faculty of Science & Mathematics, Universiti Pendidikan Sultan Idris, 35900 Tanjong Malim, Perak, Malaysia.
\textsuperscript{b}Faculty of Education, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia.

Abstract

Interactive multimedia module with pedagogical agent (IMMPA) named EC Lab was developed in order to assist students in the learning of Electrochemistry. A non-equivalent pre-test post-test control group design investigation was carried out in order to gauge the effects of EC Lab on students’ understanding and motivation in the learning of Electrochemistry. Some 127 Form Four students from two secondary schools were involved in the study. Instruments involved were achievement tests, motivation questionnaires and EC Lab. Results showed significant difference between control group and treatment group in the understanding of concepts in the learning of Electrochemistry.

Keywords: Electrochemistry, interactive multimedia module, pedagogical agent

1. Introduction

Chemistry is the science of matter concerned with the composition of substances, structure, properties and interactions between them. Chemistry should be taught in three representation levels, macroscopic, microscopic and symbolic (Johnstone, 1993). Electrochemistry is a study of inter-conversion of chemical energy and electrical energy which occurs in electrolysis and voltaic cells (Tan et al., 2007). Studies (Lee & Kamisah, 2010; Lin et al., 2002; Roziah, 2005) showed that the topic is difficult to learn because the concepts are abstract. Students encounter misconceptions in the learning of Electrochemistry especially on microscopic and symbolic levels (Lee & Mohammad Yusof, 2009; Lee, 2008; Lin et al., 2002).

Although the use of multimedia modules is able to assist students in visualizing the abstract concepts, but students lack sufficient metacognitive awareness and comprehension monitoring skill to make effective choices (Hill & Hannafin, 2001; Land, 2000). Students as novice learners do not always make connections to prior knowledge in ways that are productive for learning (Land, 2000). As a result, pedagogical agents (PAs) are designed to facilitate learning in computer-mediated learning environments (Chou et al., 2003; Craig et al., 2002; Moundridou & Virvou, 2002). PAs are animated life-like characters that portray human characteristics when interacting with the users. PAs in the multimedia module serve to enhance students’ metacognitive awareness of what they know and what they should know for the topic being studied. Hence, an interactive multimedia module with pedagogical
agents (IMMPA) with different roles of PAs, named EC Lab was developed in order to assist students in the learning of Electrochemistry.

2. Methodology

2.1. Research design

The study is a non-equivalent pre-test/post-test control group design (Campbell & Stanley, 1963). Samples in the treatment group learnt Electrochemistry using EC Lab developed by the researcher. On the other hand, the same topic was taught by a Chemistry teacher using the traditional method for the students in the control group.

2.2. Sample of the study

One hundred and twenty seven (50 male and 77 female) form four students (16 years old) from two secondary schools were involved in the study. Two classes randomly selected as control groups and another two classes as treatment groups. Each school had one treatment group and one control group taught by the same Chemistry teacher.

2.3. Research Instruments

2.3.1. Achievement tests

There are two structured questions in the achievement tests. The questions test knowledge on electrolytic cell and voltaic cell concepts at three representation levels. The KR-20 reliability index is 0.65 for the pre-test and 0.71 for the post-test. The questions in the tests were checked by lecturers and teachers to maintain the content validity.

2.3.2. Motivation questionnaire

There are six subscales involved in the motivation questionnaire, namely intrinsic goal orientation, extrinsic goal orientation, task value, control of learning belief, self-efficacy for learning and performance and test anxiety. The questionnaire was taken from the study by Sadiah and colleagues (2009) and the Cronbach’s alpha for the motivation questionnaire is 0.87.

2.3.3. EC Lab

There are five sub units in the EC Lab: (1) Electrolytes and Non-Electrolytes, (2) Electrolysis of Molten Compounds, (3) Electrolysis of Aqueous Solutions, (4) Voltaic Cells and (5) Types of Voltaic Cells. There are two PAs in the EC Lab, namely Professor T (Electrochemistry expert) and Lisa (learning companion). Students are free to choose the PA they want to accompany them in the learning of Electrochemistry when using the EC Lab.

3. Results and discussion

3.1. Achievement tests

An independent-samples t-test was conducted to compare the post-test results for treatment and control groups. There was a statistically significant difference in scores for treatment (M = 46.01, SD = 29.94) and control groups [M = 35.90, SD = 18.44; t(105.06) = 2.30, p = 0.05].
Overall, students can answer the questions at macroscopic level. Majority of them can identify the anode and cathode for electrolytic cell, positive and negative terminal for voltaic cell. Besides that, they were able to predict the color change of the electrolyte after some time. However, students from the treatment group were found to be more scientific in explaining the color change based on Electrochemistry concept at microscopic level.

Students from the treatment group have better conceptual understanding compared to the control group, especially at microscopic level. They understand the concept of the flow of currents in the conductors and in the electrolytes at microscopic level compare to their counterparts. Students in control group tended to draw the flow of electrons in the electrolyte or they reversed the direction of the flow of electrons. They assumed that the electrons flow in the electrolyte to complete the circuit (Lee & Mohammad Yusof, 2009; Lee, 2008).

On understanding the process happening at both electrodes during the electrolysis process, students from the treatment group can explain the reasons for the observations at microscopic level, describing the movement of ions and processes happening at both electrodes. On the other hand, students from the control group tended to give the conclusion as the reason for the observation given.

Results showed that students are still weak in understanding the concept of electrolyte in voltaic cell. Students assumed that water molecules are not involved in the electrolysis process (Garnett & Treagust, 1992; Sanger & Greenbowe, 1997; Lai, 2003; Lee & Mohammad Yusof, 2009; Lee, 2008), and hence they did not draw the hydrogen ions and hydroxide ions from the water molecules in the electrolyte. Overall, students from both groups were able to transform the oxidation and reduction processes into half-equations, showing that they can answer the questions at symbolic level. However, only students from treatment group can explain the selection of ions to be discharged at both electrodes and terminals based on the position of ions in the Electrochemical Series.

Micro-World in some of the sub units shows the movement of ions in the electrolyte during the electrolysis process. Students can visualize (Lerman, 2001) the process of gaining of electrons at cathode and releasing of electrons at anode microscopically. IMMFA EC Lab makes the abstract concepts ‘concrete’ because students can watch the whole process visually at three representation levels (Bowen 1998; Burke et al. 1998; Rodrigues et al. 2001; Russell et al. 1997). Hence, students learning Electrochemistry with animations and simulations in the multimedia module will gain higher achievements compared to those learning using the traditional method (Hasnira, 2005; Sanges & Greenbowe, 2000).

### 3.2. Motivation questionnaire

Independent samples t-test table shows that there was no significant difference in post-motivation mean scores for the treatment group (M = 3.68, SD = 0.39) and the control group [M = 3.59, SD = 0.38; t (125) = 1.43, p = 0.05].

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>t value</th>
<th>Sig (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>64</td>
<td>3.68</td>
<td>0.39</td>
<td>1.429</td>
<td>0.156</td>
</tr>
<tr>
<td>Control</td>
<td>63</td>
<td>3.59</td>
<td>0.38</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Students showed the highest mean score in extrinsic goal orientation (treatment group: M = 4.16, SD = 0.61; control group: M = 4.04, SD = 0.63) among all the subscales, indicating that they were trying to show to others that they can perform well in Chemistry. They expected rewards and praises from their parents and teachers if they get good grades in the subject. The examination-oriented education system in the country (Anthony, 2006; Keeman, 2007) causes the students to learn to get good grades in the examinations. Results also showed that students were more extrinsically motivated than intrinsically motivated (Chang, 2005). Students were more concerned with the rewards and grades rather than enjoyment in learning Electrochemistry.

Control of learning belief obtained the second highest mean scores for the control and treatment groups with 4.01 (SD = 0.58) and 4.07 (SD = 0.59) respectively. With high control beliefs, students are confident in employing learning strategies to manage their learning and they believe that this will bring about the desired results. As such, they may self-regulate more when their control beliefs are improved (Melissa Ng & Kamariah, 2006).

Anxiety subscale measures students' nervous and worried feelings towards examinations. Students who are not well prepared or who expect to fail are more likely to have higher anxiety than those who are well prepared and expect to succeed (Shores & Shannon, 2007). Previous research showed that test anxiety is related to high extrinsic goal orientation (Kivinen, 2003) and the control of learning belief (Melissa Ng & Kamariah, 2006) and it was proven in this study. Extrinsic goal orientation and test anxiety for treatment group were found to be positively related to each other (r = .5, p < .01). On the other hand, test anxiety was found to be positively related to the control of learning belief (r = .3, p < .01). Students are more likely to worry about examinations if they believe that the attainment of the desired grades is not within their control (Melissa Ng & Kamariah, 2006).

4. Conclusion

The results from the study showed that the EC Lab was able to increase the students’ score in the achievement test in the learning of Electrochemistry. This is parallel with studies abroad (Kizilkaya & Askar, 2008; Moreno et al., 2000) where students were found to achieve higher performance when learning with a tutorial supported by PAs. However, the EC Lab was not able to increase students’ motivation level compared to students learning Electrochemistry via traditional methods. Further investigation, such as interviewing the students from treatment group should be carried out in order to assess the weakness of the EC Lab in terms of motivating students in the learning of Electrochemistry. Study regarding PAs is still new among researchers in East Asia. Studies associated with PAs should therefore be increased in order to involve various fields and should be applied in various stages of education so as to benefit students from diverse backgrounds.

References


