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Interactive Multimedia Module with Pedagogical Agent in Electrochemistry

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1. Introduction

Members of the young generation who are literate in science and technology play a vital role in developing countries like Malaysia. The education system in Malaysia therefore puts greater emphasis on science and mathematics. In consonance with the National Education Philosophy, science education in Malaysia nurtures a science and technology culture by focusing on the development of individuals who are competitive, dynamic, robust and resilient and able to master scientific knowledge and demonstrate technological competencies. It is hoped that this young generation can help the country achieve Vision 2020 as an advanced industrial country in the world.

1.1 Chemistry curriculum in Malaysia

Like other countries once colonized by the British, science as a subject was introduced by the British to Malaysia. Practices in science education are therefore similar to British science education, and both syllabus and rubrics are borrowed from the British to make modifications based on local conditions. In Malaysia, the Science subject was introduced by colonialists in the early 1970s (Lewin, 1975) in secondary schools. Formal science education was started in primary schools for Year Five students. Science as a subject was introduced on a trial basis in selected schools in 1993 and introduced in all schools in 1995 (Khalijah, 1999). Science for primary school curriculum consisted of five main themes: (1) The Living System, (2) The Physical System, (3)The World of Matter, (4) The Earth, and (5) Technology. Teaching methods included directed investigation, discovery learning, group projects, experimenting, simulation and role play to encourage discussions among students and application of rules in decision-making. integrated science, modern physics, modern chemistry, modern biology and modern science were gradually introduced in secondary schools throughout the country. The Table 1 shows the history of science as a subject in Malaysia.

Chemistry as a subject is taught at upper secondary level for science stream students. The themes for the chemistry syllabus are: (1) Introducing Chemistry, (2) Matter Around Us, (3) Interaction between Chemicals, and (4) production and Introduction and Management of Manufactured Chemicals. The chemistry curriculum has been designed not only to provide opportunities for students to acquire scientific knowledge and skills, develop thinking skills and thinking strategies, and apply the knowledge and skills in everyday life, but also to

Subject	Stage	Basis	Year introduced
Integrated Science	Form 1 - 3	Scottish Integrated Science	1969
Modern Physics, Modern Chemistry, Modern Biology	Form 4 -5 (Science stream)	Nuffield Physics / Chemistry / Biology 'O' Level	1972
Modern Science	Form 4 – 5 (Art stream)	Nuffield Secondary Science	1974

Table 1. History of science education in Malaysia

inculcate in them noble values and the spirit of patriotism (Mahzan, 2005). 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). Macroscopically, the chemical process can be observed and sensed by our sensory motors. The arrangement and movement of particles and the interactions among them can be explained in the microscopic level. All the chemical processes involved can be represented by symbols, numbers, formulae and equations symbolically.

1.2 Study of electrochemistry

Electrochemistry is a study of inter-conversion of chemical energy and electrical energy occurs in electrolysis and voltaic cell (Tan et al., 2007). Previous studies (Bojczuk, 1982; Lee & Kamisah, 2010; Lin et al., 2002; Roziah, 2005) showed that the topic is difficult to learn because the concepts are abstract. Students often encounter misconceptions in the learning of this topic (Garnett & Hackling 1993; Garnett & Treagust 1992; Garnett et al. 1995; Lee & Mohammad Yusof 2009; Lee 2008; Lin et al. 2002; Sanger & Greenbowe 1997a; Sanger & Greenbowe 1997b). Macroscopically, students need to study the concepts of electrolytes and non-electrolytes, the electrolysis process and voltaic cells. Microscopically, they need to understand the movement of ions and electrons during the electrolysis process. Besides that, they also need to transform the process into chemical formulae and equations symbolically. Students face difficulties in understanding the abstract chemical processes especially on microscopic and symbolic levels (Garnett & Hackling 1993; Garnett & Treagust 1992; Garnett et al. 1995; Lee & Mohammad Yusof 2009; Lee 2008; Lin et al. 2002; Sanger & Greenbowe 1997a; Sanger & Greenbowe 1997b). Generally, some common misconceptions or problems faced by students in learning Electrochemistry are: (1) students are always confused between the flow of current in the conductors and in the electrolytes; (2) they cannot identify the anode and cathode/positive and negative terminal in the cell; (3) they cannot describe and explain the process happening at the anode and cathode; (4) they mix up the oxidation and reduction process at the electrodes; and (5) they are unclear about the concept of electrolyte (Lee & Mohamad Yusof, 2009; Lee, 2008).

Students' major problem in learning abstract chemistry topics is the ability to visualize the concepts, that is, to form a mental image or picture in the mind (Lerman, 2001). Chemistry is a visual science (Wu & Shah, 2004). In educational practice, visualization is applicable to one of the following situations: (a) the experiment is too long or too short; (b) the dimensions of the examined object are too small or too large; (c) the environment of the experiment is not accessible; (d) the parameters of the experiment or its effects are not directly available to the observer's senses; (e) there is a need for multiple revisions of the experiment; (f) the experiment is difficult to arrange or revise effectively; (g) the experiment is dangerous; and (h) the experiment is too expensive (Burewicz & Miranowicz, 2002). In the context of Electrochemistry, the dimension of the examined objects (movement of particles) is too small and the parameters of the experiment are not directly available to the observer's senses in which the changes of the process are at the microscopic level. Hence, the teaching and learning of Electrochemistry should be aided with the use of a multimedia module. This enables the students to visualize the abstract chemical processes by using the application of multimedia elements in the module.

1.3 The use of ICT in teaching and learning

The use of Information and Communication Technology (ICT) is aiding understanding and explanations of concepts, especially visualizing abstract concepts and processes (using models, simulations, games, digital video and multimedia adventures) (Oldham, 2003). Hence, designing instructions using multimedia becomes a trend in this ICT era. Application of multimedia in education through World Wide Web, CD-ROMs, DVD and virtual reality can help students visualize the abstract concepts especially in the learning of chemistry. The use of multimedia creates the environment where students can visual the abstract chemical processes via animation and video in macroscopic, microscopic and symbolic levels (Bowen, 1998; Burke et al. 1998; Rodrigues et al. 2001; Russell et al. 1997). Studies (Doymus, 2010; Gois & Giordan, 2009; Lerman & Morton, 2009) have been carried out and results showed that animation and simulation using ICT can help students to visualize and hence enhance students' understanding in learning abstract chemistry topics.

The use of ICT especially the multimedia modules is able to assist students in visualizing the abstract concepts; however, the rate of using multimedia modules in the schools is still very low (Lee & Kamisah, 2010). Teachers are not interested in using the modules available in the market in the learning process because they find that these modules are too formal, not interesting and do not follow the syllabus (Norsiati, 2008; Roziah, 2005). Following the Teaching and Learning of Science and Mathematics using English implemented by the government since 2003, the government delivered related teaching multimedia modules to the schools. Some of the teachers used the module provided by the government to teach Electrochemistry. But, there were a lot of problems faced by the teachers in using the module. Some of them complained that the buttons in the module were not functioning, the videos were stuck when playing, the teachers do not have enough time to set up the projector and laptop in the laboratory etc. Hence, the rate of using multimedia module in the teaching of Electrochemistry was low among the Chemistry teachers (Lee & Kamisah, 2010). Furthermore, students lack of sufficient metacognitive awareness and comprehension monitoring skills in order to make effective choices (Hill & Hannafin, 2001; Land, 2000). They lack the skills to find, process and use information and ideas. Students as novice learners do not always make connections with prior knowledge or everyday experiences 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; Johnson et al., 2000; Moundridou & Virvou, 2002; Predinger et al., n.d., Slater, 2000). The use of PAs in the interactive multimedia module in this study makes the module different from the modules already available in the market.

1.4 Pedagogical agents in interactive multimedia module

Pedagogical agents are animated life-like characters designed to facilitate learning in computer-mediated learning environments. They show human characteristics in terms of appearance such as changes in facial expressions, gestures and body movements when interacting with the users. Users can communicate with the agent via speech or on-screen text. The appearance of PAs is varied in terms of gender (male or female), realism (cartoon and realistic) and ethnicity (African-American and Caucasian) (Baylor, 2005). Normally, PAs are designed as experts (Baylor, 2005; Baylor & Kim, 2004; Chou et al., 2003; Hayes-Roth et al., 2002; Kim et al., 2006; Kizilkaya & Askar, 2008; Moreno et al., 2000; Moreno & Mayer, 2005) who are knowledgeable in specific areas in order to provide guidance to students. However, there are also PAs which act as co-learners (Chou et al., 2003; Kim et al., 2006; Maldonado & Hayes-Roth, 2004; Maldonado et al., 2005; Xiao et al., 2004) or motivators (Baylor, 2005; Baylor & Kim, 2004; Kizilkaya & Askar, 2008). The co-learners or motivators accompany the students, encourage and motivate them to be involved in the learning process.

PAs in a multimedia module serve to enhance students' metacognitive awareness of what they know and what they should know for the topic being studied. One strategy for providing metacognitive guidance involves embedding support, or scaffolds for procedural, strategic, or metacognitive control (Land, 2000). This guidance or support is provided by the PAs in the module. PAs could make learners aware of the opportunities presented to them, provide advice for the learners on the tools to be used, and explain the functionalities of the tools in an open learning environment (Clarebout & Elen, 2007).

Studies abroad were carried out by several research groups using PAs in multimedia software for a variety of subjects such as environmental sciences (Moreno & Mayer, 2000), language (Maldonado et al., 2005; Predinger et al., n.d.), ecosystem (Biswas et al., 2004), art (Hayes-Roth et al., 2002), ecology (Clarebout & Elen, 2007), mathematics (Kim et al. 2006; Atkinson, 2002), space (Kizilkaya & Askar, 2008). In Malaysia, studies related to pedagogical agents have been done in Islamic Education (Mohd Feham, 2006) and Physics Education (Farah et al., 2008; Nabila Akbal et al., 2008). Studies conducted by Kirk (2008) and Baylor (2005) give students the freedom to choose their preferred PAs to assist them in the learning process. However, these agents are designed to differ only in terms of appearance (the image of an anthropomorphic pig, a green alien, and a robot), gender (male and female), ethnicity (African-American and Caucasian) and realism (real or cartoon), but were similar in terms of role. Studies on electrochemistry and the freedom to choose different roles of PAs still cannot be found. 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.

1.5 Objective of the study

The objectives of the study are listed below:

a. Identify the effectiveness of IMMPA EC Lab in improving students’ achievement levels in the learning of Electrochemistry topic.

b. Identify the effectiveness of IMMPA EC Lab in improving students' motivation level in the learning of an Electrochemistry topic.

2. Methodology

2.1 Research design

The study is a quasi experiment non equivalent pretest/post-test control group design (Campbell & Stanley, 1963). Normally a school will arrange the classes according to students' achievements and subjects selected. Hence, it was impossible to run the study using true experimental designs. There are two groups of samples: a treatment group and a control group. Samples in the treatment group will learn an Electrochemistry topic using IMMPA EC Lab developed by the researcher. On the other hand, Electrochemistry will be taught by a Chemistry teacher using the traditional method for the students in the control group.

2.2 Sample

The selection of samples was based on some criteria. For instance, overall students' achievement in Lower Secondary Examination (Peperiksaan Menengah Rendah, PMR); the ratio of female and male students; the experience of a Chemistry teacher who taught the classes and the number of computers in the computer laboratory. Finally, 127 (50 males and 77 females) Form Four students (16 years old) from two secondary schools were involved in the study. The students were From Four classes, with two classes randomly selected as control groups and two classes as treatment groups. There were 24 males and 39 females in the control group, 26 males and 38 females in the treatment group. Each school has one treatment group and one control group taught by the same chemistry teacher. Both teachers had more than 20 years of experience in teaching chemistry.

2.3 Materials

2.3.1 Achievement test and specific entry test

Materials utilized in the study are the pretest/post-test, specific entry test, motivation questionnaire and the IMMPA titled EC Lab. There are two structured questions in the achievement test. The questions test knowledge on Electrolytic Cell and Voltaic Cell concepts at the macroscopic, microscopic and symbolic levels. Macroscopically, the students need to identify the anode and cathode in the cell and describe the observations at both electrodes during the electrolysis process. Microscopically, they need to draw the ions that exist in the electrolyte and the direction of the flow of the electrons in the circuit. Symbolically, they have to represent the oxidation and reduction process at the electrodes by writing the half-equations. Questions in the pretest and the post-test are similar in terms of the difficulty level and the concepts tested. The only difference is the types of electrodes and electrolyte used in the cells. A reliability analysis was carried out and the KR20 is 0.65 for the pretest and 0.71 for post-test. The specific entry test consists of ten multiple-choice questions testing on some basic skills that will be applied in the Electrochemistry learning process.

2.3.2 Motivation questionnaire

The motivation questionnaire is a Likert scale questionnaire. There are three sub dimensions involved, namely Adhered Value, Expectancy Components and Affective Components.

Adhered Value consists of three subscales, namely intrinsic goal orientation, extrinsic goal orientation and task value. On the other hand, Expectancy consist of control of learning belief and self-efficacy for learning and performance. Affective involve test anxiety. There are 28 items in the questionnaire with Likert scale provided, where 1 – Strongly Disagree, 2 –Disagree, 3 – Not Sure, 4 – Agree, and 5 – Strongly Agree. Items in the questionnaire have been taken from the study of Sadiah and colleagues (2009) which were translated from the original instrument by Pintrich and DeGroot (1990). In this study, the researcher used the motivation section only and changed the scale from seven points to five points. The Cronbach Alpha reliability coefficient for the motivation questionnaire is 0.87.

2.3.3 EC Lab

EC Lab was developed by the researcher by using the combination of two instructional design models: the Kemp Model and Gerlach and Ely Model. The reasons for using the combination of these two models are that they are classroom-oriented models (Gustafson & Branch, 1997) with their own strengths. The Kemp Model describes elements, not 'step, stage, level or sequential item' in an instructional design (Kemp et al., 2004). The oval shape of the model indicates the independency of the elements in the model. It is a non-linear model with no starting and ending point. All the processes of designing, developing, implementing and evaluating can be done concurrently and continuously. The Gerlach and Ely Model is suitable for the novice instructional designers who have knowledge and expertise in a specific context (Qureshi, 2001, 2003, 2004). This model is classroom-oriented and is suitable for teachers at secondary schools and higher education institutions. The Gerlach and Ely Model focuses more on the instructional materials and resources without identifying the instructional problems. Hence, the researchers combined the two models as the instructional design model to develop the EC Lab. The conceptual framework of the combination of these two models used in the study is presented in Figure 1 below.

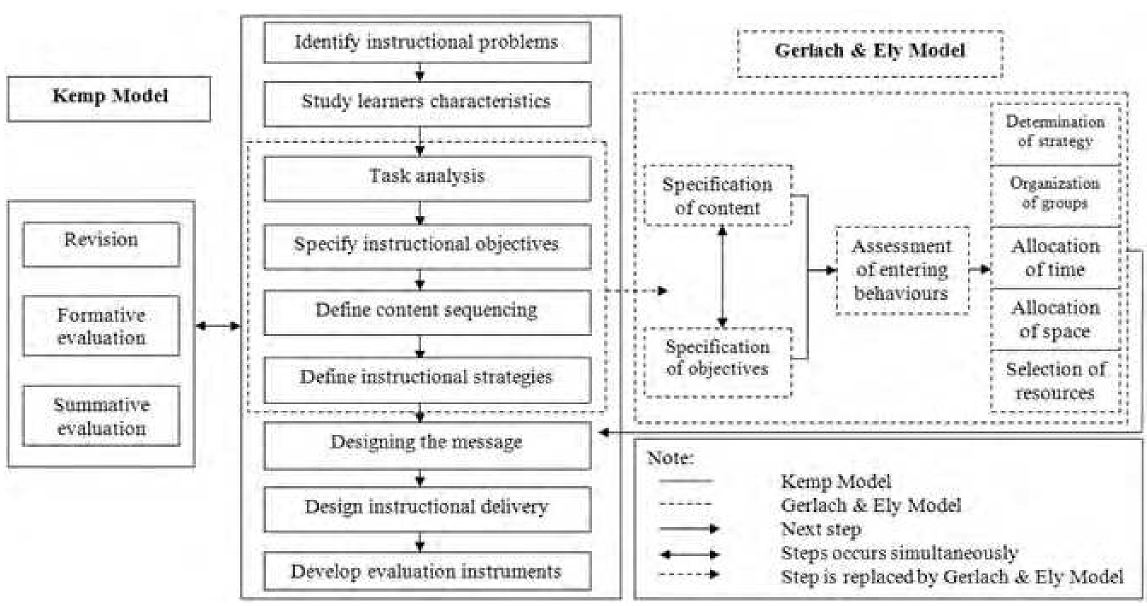

Fig. 1. Conceptual framework of combination of two instructional design models

There are two PAs in the EC Lab, namely Professor T and Lisa. Professor T is a sixty year-old male PA who acts as an expert in Electrochemistry. He gives accurate information and explains new concepts to the students. Professor T speaks slowly in a formal way with little body gestures and facial expressions. On the other hand, Lisa is a fifteen-year old female youth who speaks with an energetic voice. She is a learning companion in the EC Lab. She learns together with the students, gives motivation and encouragement to the students to complete the tasks and exercises in the module. Students are free to choose the PA they want to accompany them in the learning of Electrochemistry after they key in their name in the module. The interface for the choosing of PAs is shown in the Figure 2.

Fig. 2. Interface for PAs selection

The main menu for the EC Lab consists of tutorial, experiment, exercise, quiz, memo and game. 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. All the information delivery for the sub units is presented in the tutorial session. The experiment session consists of five experiments in Electrochemistry. The first experiment about the concept of electrolyte and non-electrolyte is done through the simulation. Another three experiments investigating the factors that determine the ions to be discharged at the electrodes and experiment for simple voltaic cell are hands on investigation. The students were guided by the PAs to carry out the experiments in the chemistry laboratory and they need to apply scientific process skills and manipulative skills during the investigations. There is a session named 'Micro-World' (Figure 3) in the module. When students click on magnifying glass button, they will be shown the moving of electrons and ions in microscopic level. This 'Micro-World' session describe the detail process happened in the cell during the electrolysis process. After the information delivery process, students will do some exercises to enhance their understanding on the concepts learnt. Quiz will be given at the end of every sub unit. Each quiz is divided into three levels. The first level is to let the students do some reflections on what they have learnt in the sub unit. The students then need to compare their prior idea with the new idea to review whether the conceptual change has occurred. The second level of the quiz consists of five simple multiple-choice questions and some elementary structured questions. Students need to click the answers for the multiple-choice questions and write down the answer for the structure

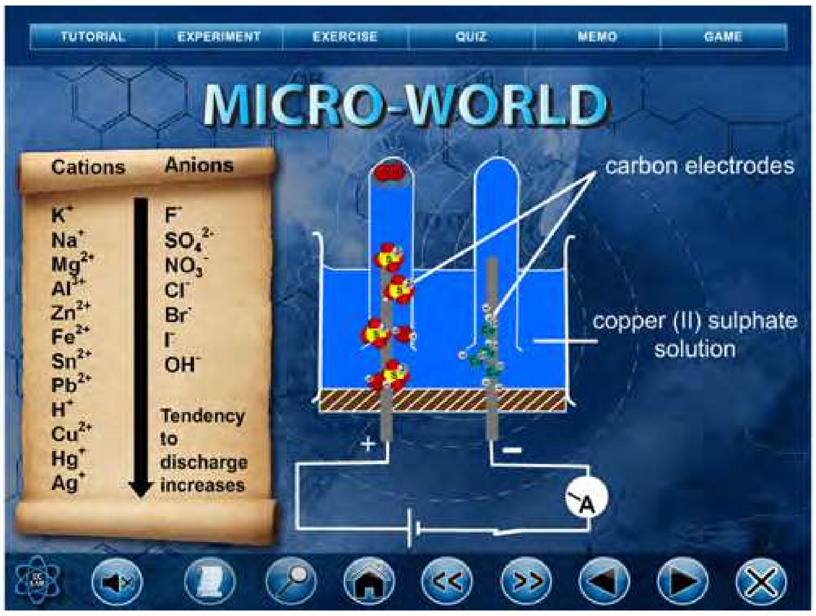

Fig. 3. Micro-World shows the process happened in the cell in microscopic level

questions. The third level of the quiz is more challenging, with some difficult structured questions and essays. Students can check their answers by clicking on the SOS button. A memo is created to give some hints or tips on learning of some of the Electrochemistry concepts. For instance, mnemonics (Figure 4) are given to help the students in memorizing the list of anions and cations in the Electrochemical Series. There are four games in the game session to let the students relax their mind after the learning process. The games are applications of Electrochemistry concepts; for instance, one of the games asks the students to set up an electrolytic cell and a voltaic cell with the apparatus given.

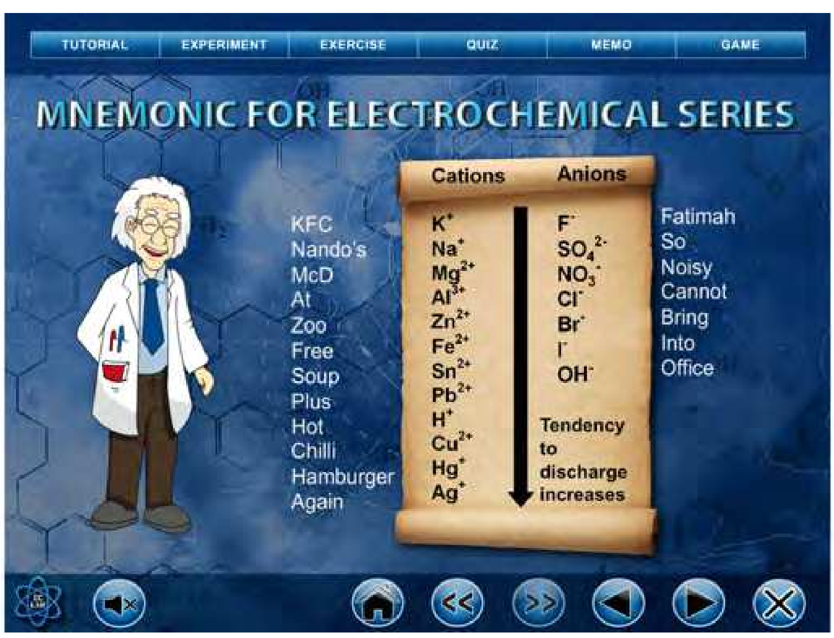

Fig. 4. Mnemonics in the memo to help students memorize the list of Electrochemical Series

The complete flow of each sub unit follows the five phases in the learning process created by Needham (1987). The five phases are orientation, elicitation of ideas, restructuring of ideas, application of ideas and review. In the EC Lab, the *Think about it* session (Figure 5) is the orientation phase. The students will be shown some pictures that are familiar to them. Those pictures are related to the concepts to be learnt in every sub unit. Then, in the *Do you still remember* session, the students will be reminded of some concepts that they have learnt before. Those concepts are related to the new concepts to be learnt in the sub unit. Next, in the *Give me your ideas* session (Figure 6), the students are given the chance to give their ideas regarding some activities that are related to the concepts to be learnt. Students need to type, click or drag the pictures to give their ideas regarding the concepts being tested. Students can then check their answers to evaluate themselves based on the feedback given by the PAs. Then, in the *Are you sure* session, the students need to give some ideas, make some guesses or predictions on some outcomes of the situations. In order to examine their ideas, guesses and predictions, the students need to carry out some investigations in *Let's do it* or watch related videos in *Show time* sessions. In these two sessions, the students will be exposed to the conflict situations if their ideas, guesses or predictions are different from what is being shown in the experiments or videos. Hence, conceptual change should happen here and the students need to modify, extend or replace their existing ideas. Then, reinforcement of the constructed ideas will be done in the *Practice makes perfect* session. The students will apply the concepts learnt in new situations and examples. Students need to do exercises related to the concepts learnt in each sub unit. Lastly, *Before and after* session is created to enable the students to reflect upon the extent to which their ideas have changed. The students need to answer certain activity questions again and compare their prior answers to the new answers. *Testing yourself* and *Challenge yourself* sessions contain multiple-choice questions, structured questions and essay questions to let the students evaluate themselves on the concepts learnt.

Fig. 5. Pictures shown in *Think about it* session in Sub Unit 4

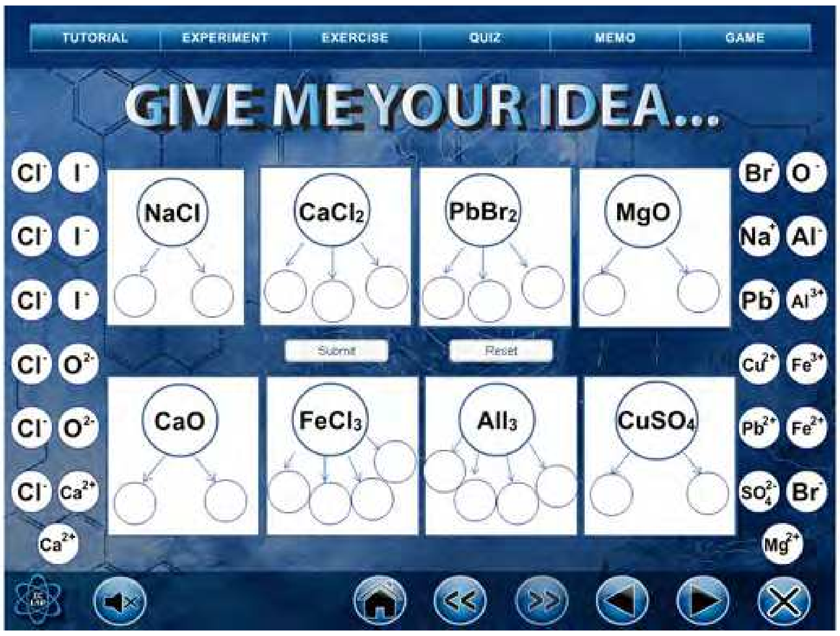

Fig. 6. Students need to drag the answers to the correct spaces

3. Procedure

The study was carried out in the schools using chemistry periods during the normal school hours. Two chemistry teachers were involved in the study. The same chemistry teacher handles both the treatment and control groups in one school. The teacher used the traditional 'chalk and talk' method to teach the control group and EC Lab module to teach the treatment group during the teaching and learning process of Electrochemistry. The procedure of the study is shown at the flow chart.

Samples in both treatment and control groups were given one hour to answer the pretest. After that, they need to answer the specific entry test and motivation questionnaire in about 15 minutes respectively. The students who had poor results for the specific entry test were given some revision notes. They were told to study the revision notes before the treatment sessions. In the next meeting, students in the treatment group went to the computer lab to study the Electrochemistry topic using the EC Lab. The user manual was given to the students, followed by a briefing on how to use the EC Lab. Then, students were told the sub unit to be learnt on that day to ensure every student learn the same sub unit. Then, students were free to explore the first sub unit in 80 minutes. Since the number of computers in the school is limited, each computer was shared by two students. They put on the earphone to listen to the script delivered by the PAs. On the other hand, students in the control group were taught by their teacher using the traditional method. Each meeting is about 80 minutes (two periods) and students learned one sub unit in each meeting either with their teacher or with EC Lab.

Students learnt the second sub unit in the next meeting. The teaching and learning process for a treatment group was carried out in computer laboratory while for the control group, they used the chemistry laboratory to study Electrochemistry. Sub unit three consists of three experiments in studying the factors that determine the ions discharged at the electrodes. Students therefore need to attend three meetings to complete sub unit three in

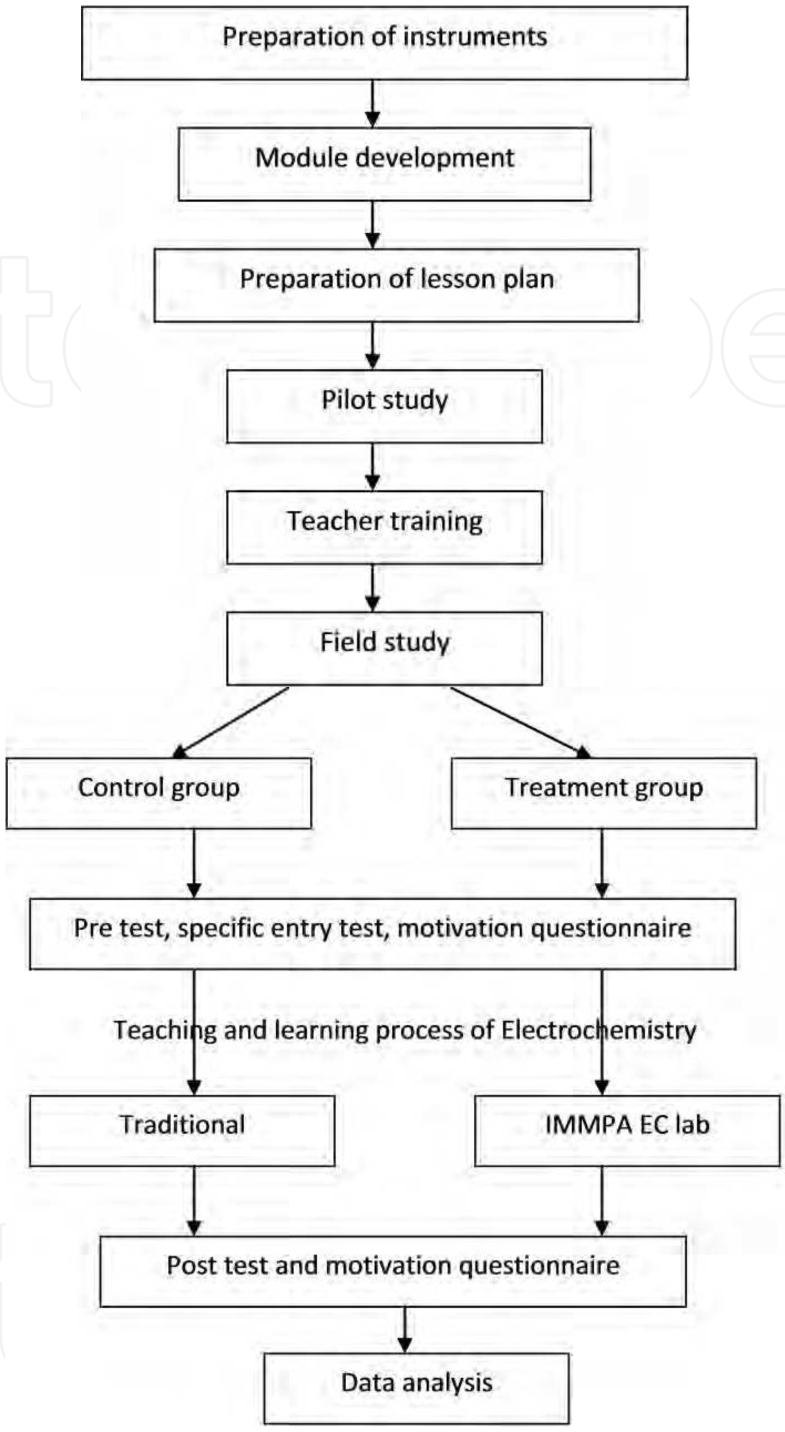

Fig. 7. Flow chart of the procedure

EC Lab. As a result, the third, fourth and fifth meetings were conducted at the chemistry laboratory. Students need to carry out the experiments to investigate the three factors that determine the ions to be discharged at the electrodes. Students learnt sub unit four in the sixth meeting. There was an experiment regarding simple voltaic cell in the unit. Hence, students conducted the experiment in the chemistry laboratory. For the seventh meeting, students explored sub unit five in EC Lab about types of voltaic cell. Students in the control group were given notes and lecture for the same sub unit.

After completing the sub units in the Electrochemistry topic, students need to answer the post-test and motivation questionnaire in the next meeting. As usual, students in both control and treatment groups were given 60 minutes to answer the post-test and 15 minutes to answer the motivation questionnaire. All the pretest, post-test, specific entry test and questionnaire were collected and analyzed. The pretest and post-test were used to analyze students' achievement level while the motivation questionnaire was used to analyze students' motivation level in the learning of Electrochemistry. The results were compared between treatment and control groups to identify the effectiveness of EC Lab in increasing students' knowledge and motivation in the learning of Electrochemistry.

4. Results and discussion

4.1 Specific entry test

Specific entry competencies are prerequisite knowledge, skills and attitudes that learners must possess to benefit from the training (Morrison et al., 2007). Students' specific entry competencies were identified through the specific entry test. Students were given this test in order to assess their prior knowledge regarding concepts that will be applied in the learning of Electrochemistry. Concepts being tested were related to proton number, nucleon number, arrangement of electrons, chemical formulae and chemical equation. Students need to have the skills to write chemical formulae and chemical equations in describing the process that takes place in the electrolytic cells. The test consisted of ten multiple-choice questions. Each question was followed by four alternative answers. Each correct answer was given one point and no point was given for the wrong answer. Both control and treatment groups have the same questions in the test.

Table 2 shows the t-test table to compare the specific entry test result for treatment and control group. There was no significant difference in scores for treatment ($M = 61.25$, $SD = 23.40$) and control group [$M = 58.57$, $SD = 23.82$; $t(125) = 0.64$, $p = 0.05$]. The magnitude of the differences in the means was very small (eta squared = 0.003). These show that students in both groups have similar level of prior knowledge before they learn Electrochemistry. The students' results ranged from 10% to 100%. The results showed that the students were still weak in the concept of proton number (Item 7, only 39.4% of the students answered correctly). Students who scored less than 50% ($n = 39$) of the specific entry test were given remedial help before they started with the treatment sessions. They were given some revision notes for Chapter Two: The Structure of Atom and Chapter Three: Chemical Formulae. Students were reminded to do revisions before they started the lesson for Electrochemistry.

Group	N	Mean	Std. Deviation	t value	Sig (2-tailed)
Treatment	64	61.25	23.40	0.639	0.524
Control	63	58.57	23.82		

Table 2. t-test table for specific entry test between control group and treatment group

4.2 Achievement test

A series of paired-sample t-test was conducted to evaluate the impact of the interventions on the students' scores in the achievement test. There was a statistically significant increase in test scores from pretest (M = 4.46, SD = 3.52) to post-test [M = 35.9, SD = 18.44, $t(62) = 12.57$, $p < 0.05$] for the control group. On the other hand, students' achievement in the treatment group also showed statistically significant increase in test scores from pretest (M = 7.11, SD = 4.00) to post-test [M = 46.01, SD = 29.94, $t(63) = 11.03$, $p < 0.05$]. The eta squared statistic (.50) for both groups indicated a large effect size. Although the overall results for the post-test were better compared to the pretest for both groups, 52.4% and 43.75% of them from control group and treatment group respectively still failed the post-test. The results for the post-test ranged from 4.26% to 61.70% for the control group and 2.13% to 93.62% for the treatment group. Both groups showed significant increase results for the achievement test from pretest to post-test indicating that students' knowledge in Electrochemistry was increased after they gone through the interventions. However, the results for the post-test for treatment group were higher than control group. Table 3 shows the mean scores for post- test between control group and treatment group.

Group	N	Mean	Std. Deviation	t value	Sig (2-tailed)
Treatment	64	46.01	29.94	2.295	0.024**
Control	63	35.90	18.44		

Table 3. t-test table for post-test between control group and treatment group

An independent-samples t-test was conducted to compare the post-test result for treatment and control group. There was a statistically significant difference in scores for treatment (M = 46.01, SD = 29.94) and control group [M = 35.90, SD = 18.44; $t(105.06) = 2.30$, $p = 0.05$]. The magnitude of the differences in the means was small (eta squared = 0.04). Questions in the test consisted of items testing Electrochemistry concepts in macroscopic, microscopic and symbolic levels. Students need to understand the whole process happens during the electrolysis at both electrodes. Comparatively, students from treatment groups were more able to give reasons and explanations to their answers especially in microscopic level. For instance, when copper (II) nitrate solution was changed to concentrated copper (II) chloride solution in electrolytic cell (Item 1l), some students from both groups were able to give the correct observations at both electrodes at macroscopic level. However, students from treatment group (e.g. ET 22 & ET33) can explain the reasons to the observations in microscopic level describing the movements of ions and processes happened at both electrodes. On the other hand, students from control group (e.g. KL29) tended to give conclusion as reason for the observation given.

Since the Cl^- ion is more concentrated than OH^-, Cl^- ion is chosen for discharging to form chlorine gas (ET22).

Cl^- ions are selectively discharged as it is more concentrated even though it is placed higher at the electrochemical series (ET33).

The chlorine gas is produced (KL29).

Micro-World in some of the sub units shows the movements of ions in the electrolyte during the electrolysis process. Students can watch the process of gaining of electrons at cathode and releasing of electrons at anode microscopically. Students can visualize (Lerman, 2001) the whole process through the animations in Micro-World. IMMPA 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 multimedia module will gain higher achievements compared to traditional method (Hasnira, 2005; Sanges & Greenbowe, 2000).

4.3 Motivation

The motivation questionnaire was used to assess the students' goals and value beliefs for chemistry (especially Electrochemistry), their beliefs about their ability to succeed in the subject and their anxiety toward the test and examination on Electrochemistry. Both groups answer the similar motivation questionnaire before and after the interventions. The paired sample t-test was unable to show any significant difference between pre-motivation and post-motivation mean scores for the both groups. Mean score for control group decreased from pre motivation (M = 3.64, SD = 0.48) to post motivation [M = 3.59, SD = 0.38; t(62) = -0.98, p < 0.05]. On the other hand, mean score for treatment group increased from pre-questionnaire (M = 3.64, SD = 0.39) to post-questionnaire [M = 3.68, SD = 0.39, t(63) = 1.10, p < 0.05]. The eta squared statistic (.50) indicated a small effect size for the both groups. Although the post-motivation mean score for treatment group is slightly higher than control group, but the t-test was unable to show significant difference between the groups.

Group	N	Mean	Std. Deviation	t value	Sig (2-tailed)
Treatment	64	3.68	0.39	1.429	0.156
Control	63	3.59	0.38		

Table 4. t-test table for post-motivation mean score between control and treatment group

Independent samples t-test result in Table 4 above show that there was no significant difference in post- motivation mean scores for treatment (M = 3.68, SD = 0.39) and control group [M = 3.59, SD = 0.38; t(125) = 1.43, p = 0.05]. The magnitude of the differences in the means was small (eta squared = 0.02). Items in the motivation questionnaire consists of six subscales, namely intrinsic goal orientation, extrinsic goal orientation, task value, control of learning belief, self-efficacy for learning and performance and test anxiety. 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 to get reward and praise from the parents and teachers if they got 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. For instance item six 'Getting a good grade in this class is the most satisfying thing for me right now' had a high mean score of 4.31 (SD = 0.72) with majority of them agree (39.4%) and strongly agree (45.7%) with the statement. 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 enjoy and learn the Electrochemistry.

Control of learning belief obtained second high 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 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). Students believed that if they tried their best (Item 15, M = 4.24, SD = 0.70), and studied in an appropriate way (Item 2, M = 4.17, SD = 0.71), they will be able to learn and can understand the subject well.

Anxiety subscale measures students' nervous and worried feelings towards examination. Students with high anxiety level are not confident and are always worried about their academic results. Students who are not well prepared or who expect to fail are more likely to have higher anxiety than those students 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).

5. Conclusion

The result from the study showed that the IMMPA 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, IMMPA EC Lab was not able to increase students' motivation level compared to students learning Electrochemistry with traditional methods. Further investigation, such as interviewing the students from treatment group should be carried out in order to assess the weakness of the IMMPA 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.

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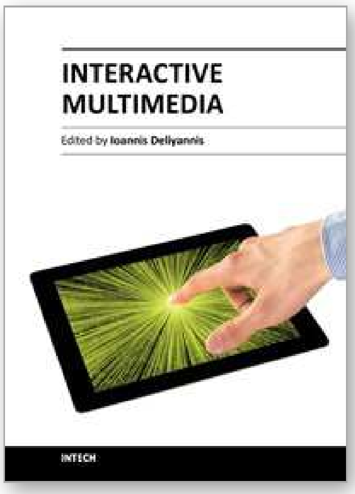

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Interactive multimedia is clearly a field of fundamental research, social, educational and economical importance, as it combines multiple disciplines for the development of multimedia systems that are capable to sense the environment and dynamically process, edit, adjust or generate new content. For this purpose, ideas, theories, methodologies and inventions are combined in order to form novel applications and systems. This book presents novel scientific research, proven methodologies and interdisciplinary case studies that exhibit advances under Interfaces and Interaction, Interactive Multimedia Learning, Teaching and Competence Diagnosis Systems, Interactive TV, Film and Multimedia Production and Video Processing. The chapters selected for this volume offer new perspectives in terms of strategies, tested practices and solutions that, beyond describing the state-of-the-art, may be utilised as a solid basis for the development of new interactive systems and applications.

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