Development and Evaluation of Web-Based Guided Inquiry-Based Environment System Embedding Educational Computer Simulation for Electrochemistry

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ABSTRACT

This paper will discuss the drawbacks of traditional method, traditional classroom and laboratory. Next, it will explain the negative impacts of traditional method toward students' learning process. The negative impacts are learning difficulties and misconceptions. Therefore, scientists had proposed several alternatives to traditional method. The most suitable alternative is computer assisted class and laboratory. Simulation is an application that is highly accepted in a computer assisted class and laboratory. Simulation possesses several advantages that are highly suitable for learning physical science, and these advantages will be discussed in this paper. Scientists argue that the most suitable approach in learning physical science using simulation is inquiry based learning approach that implements collaborative method. This paper therefore attempts to propose a web based simulation system with an inquiry-based learning approach to elevate or eliminate learning difficulties and misconceptions among students.

Introduction

Learning is a process of information seeking, gathering and transferring. These process demands learner to construct knowledge through interaction with environments, but there are also some restriction to this process. Learning difficulties and learning disabilities are terms widely used at present within adult as well as young learner circles. The terms are sometimes, but not always, used interchangeably. Learners facing both learning difficulties and misconceptions during their learning process and these problems will still exist throughout their live (Chris, 2007). On the other hand, learners' misconceptions also disturb the correct understanding about what they learn. According to Martin *et al.,* (2002), misconception can be described as ideas that provide an incorrect understanding of such ideas, objects or events that are constructed based on a person's experience including nonscientific beliefs, naive theories, mixed conceptions or conceptual misunderstandings.

Learning difficulties or learning disabilities and misconception also occur in learning science including chemistry. Chemistry is one of the most important branches of science; it enables learners to understand what happened around them. Because chemistry topics are generally related to or based on the structure of matter, chemistry proves a difficult subject for many students. Chemistry curricula commonly incorporate many abstract concepts, which are central to further learning in both chemistry and other sciences (Taber, 2002). One

of the essential characteristics of chemistry is the constant interplay between the macroscopic and microscopic levels of thought, and it is this aspect of chemistry (and physics) learning that represents a significant challenge to novices (Bradley & Brand, 1985).

The development of ICT and its integration into learning have made the above problems can be overcome to promote a better understanding in learning. A good implementation and manipulation of multimedia in learning had being proven to have a significant positive effect to students' learning. Simulation, an example of application that evolves from development of multimedia, specifically, it facilitate hand-on and mind-on activities in science and chemistry as well. Simulations have being proven effective in term of delivery and facilitating both conventional and contemporary education technology, at the same time, perspective on pedagogy and demands of society evolve and research shown that simulation possess potential to assist those changes (Michael, 2006).

Background Of The Study

Revolution of education in the 21st century have lead the world toward a new approach in education, transaction and transformation from conventional approach to a much effective and reliable contemporary approach that capable of integrating various medias and able to interact with learners' senses for a better learning, understanding and longer information retaining. The impact of this revolution cause the unilateral approach to be eliminated by bilateral approach and changes occur from teacher oriented learning to students oriented learning that based on constructivism theories (Shafie, 2009).

Constructivists argues students should be actively involved in their learning so that they are able to apply what they have learned instead of receiving knowledge in top-down delivery system from teachers (Berge, 2001). In constructivism, students learn actively through the condition called "active learning". According to Moses and Litzkow (2005), active learning is defined as students engaged in activities that are not passively listening to lectures and taking notes. Active learning element can be found in several constructivism approaches such as cooperative and collaborative learning, problem based learning and inquiry based learning (Elliot and Chu, 2009). Inquiry based learning was the most suitable approach for learning science as it can be easily incorporate with laboratory practical works as well as be suggest by scientists. Inquiry based learning capable of supporting strategies for scaffolding and promoting students' learning with application of digital resources in the process of data analysis and laboratory reporting (Annette *et al.,* 2008). In addition to these

advantages, inquiry based learning also emphasizes an open-ended exploratory experiences which help students to make connections between macroscopic data, chemical concepts, and authentic applications of chemistry itself. Connection between these elements promotes knowledge construction more effectively than 'cookbook' experiments with closed outcomes.

Constructivism had being highly suitable and compatible with the integration of multimedia in learning for a better learning. According to Dede (2007) to date, uses of information technology to enhance constructivist learning environments have centered on creating computational tools and virtual representations that students can manipulate. Simulation technology has often been associated with constructivism. This relationship is perhaps due to the fact that the technology provides students with almost unlimited access to information that they require in order to do research and test their ideas (Becker 2000).

Simulation is capable of supporting inquiry based learning as it has the ability to provide users with hand-on and mind-on activities that lead to open exploration in learning (Alessi and Trollip, 2001).Educational simulation being define by Alessi and Trollip (2001) as a model of some phenomenon or activity that users learn about through interaction with the simulation. Learn from reality compared to simulation proved to be high cost consumption, and expose students to some uncontrolled threat. On the other hand, simulation make rare events more common, reduce the complexity of learning and ability to modify time frames (Alessi and Trollip, 2001).

Simulation nowadays extensively uses in industry, engineering, training and education. Latest trend on chemistry involve application of digital technologies such as computer based simulation and visualization tools (Annette *et al.*, 2008). Better understanding of theoretical information specifically macroscopic, microscopic and representative elements can be acquire from virtual experiment (Bellett*i et al.,* 2006). Simulation proved by researches give positive effect in learns chemistry.

Unfortunately, even simulation proved give benefits in learns chemistry; students in secondary schools of Malaysia have no chances interact with simulation. Hindrance by time and space constraint, teachers tend to apply deductive with multimedia. Only teachers interact with simulations in courseware while students watch and take note. The approach deviates from constructivism concept of active learning. The deductive encourages and promotes misconceptions and learning difficulties.

Malaysian educations that still applying direct or deductive approach bring setbacks toward nation's development. Traditional classroom brings benefits as well as disadvantages cause

by its limitation (Les, 2006). Traditional Method of lecturing cannot effectively facilitate students' understanding of abstract concepts in chemistry make it less suitable for science teaching and learning (Noh and Scharmann, 1997).

On the other hand, traditional method cannot give students authentic ability or even conductivity. The conditions lead to disconnection of classroom from real-world. In traditional method, knowledge construction focuses on classroom context that deviate from context which knowledge build and apply (Henning, 1998).
Besides that, traditional laboratory also has limitation such as experiment cannot be conducted because of technical deficiencies such as hazardous risk. On the other hand, traditional laboratory inflexible for time and space constrain. Hence, it causes problems for students with poor motor abilities (Bayrak *et al.,* 2009).

All the above researches had shown how traditional classroom triggers learning difficulties in chemistry. Mean while, from the point of misconceptions, experts believe that it was cause by inappropriate mind models. Incorrect mind models are closely related to visual representation of students. Misconceptions are promoted by static visual uses in traditional classroom and books. Static visual in book proved ineffective as students need to build their mind model based on all the three level of representation (micro, macro and symbolic) (Sanger and Greenbowe, 1997).

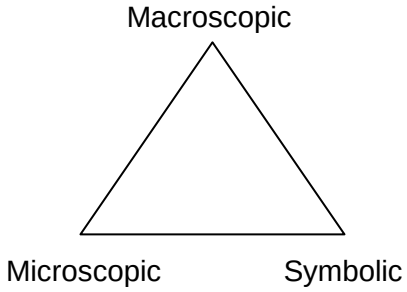

Figure 1.0: Chemistry Triangle for Understanding Abstract Concepts in Chemistry.

Students' disabilities to understand concepts according to chemistry triangle cause construction of mind model that is not scientifically correct. This condition rise misconceptions, alternative concepts or preconceptions in students' mind. The correct way of construct mental models of scientific concepts and principles are using visual representation to break the chemistry triangle.

Today's world is basically and practically a race of technology and innovation, for the sake of national development, students' learning difficulties and misconceptions should be overcome. Hence, our education needs alternative strategy to reduce both learning difficulties and misconceptions. Then, another question rise, what is the alternative that most suitable for us? Most experts suggest that computer assisted learning and computer assisted laboratory application highly effective and useful (Les, 2006; Liu, 2008; Bayrak *et al.,* 2009).

Computer assisted learning and laboratory gives access to two interactive application of multimedia; educational computer simulation and educational computer animation. Both application proved effective in reduce students' learning difficulties and misconceptions. Computer animation possesses capability of delivering abstract concepts dynamically. Mean while, educational computer simulation also can present visual of dynamic mechanism and commonly accepted. Its advantages successfully help students understand abstract concepts (Kozma and Russell, 2007).

The flexible ability of simulation in providing hand-on and mind-on activities, hypothesis testing and mental models development give this application significant effect on learning (Les, 2006). Based on research, simulation gives numerous advantages to students such as enabling students to comprehend the topic in more visual, interesting and effective way. The knowledge constructed can be practically uses as well as helping teachers to give lectures effectively and presents the experiments according to students' needs. Ultimately, simulation promotes meaningful learning and support students' problem solving skills (Bayrak *et al.,* 2009).

Now, we faces new question. After all the solutions suggested, what is the most suitable approach or strategy to support animation and simulation? Constructivist argues on active learning. There are several example of active learning as being stated before. According to previous researches, the most suitable approach is inquiry based learning.

Inquiry based learning is suggests by chemists. Through inquiry based learning, students can learn challenging concepts, make connection between macroscopic data, chemical concepts and authentic applications of chemistry (Annette et al., 2008). Inquiry-based learning best implement using team based approach; based on idea that learning is a constructive interactive process and social together with contextual factors influence learning.

Hence, a research should be conducted to prove the traditional method ineffective compared to computer aided learning or laboratory using animation and simulation in term of reducing learning difficulties that related to hypothetical-deductive thinking and reducing misconception by dynamic visual representation.

Research Objectives

This research aims to address the following objectives:

i. To develop a web based system with guided inquiry-based learning environment that embedding educational computer simulation and has functions for reducing learning difficulties and misconceptions in electrochemistry by promoting students' intellectual level
ii. To investigate student's intellectual level and misconception level after undergoing traditional method classroom.
iii. To evaluate system's efficiency in facilitating learning from the aspect of:
    a. student's achievement in test.
    b. promotion of intellectual level.
    c. misconception level.
iv. To investigate connection between students' ability and pattern of interaction with simulation.
v. To investigate either the inquiry-based learning approach can be transferred across domains (chemistry and physics).
vi. To find out the most effective model of educational computer simulation for empirical-inductive thinker to proceed to hypothetical-deductive intellectual level.

Research Rational

Integration of multimedia into teaching and learning proved significantly enhance teaching as well as learning. Multimedia possesses the potential to influence student learning and knowledge acquisition. Sensing the vast capabilities of multimedia in the educational realm, multimedia software packages have being developed as teaching tools by instructors (David and Martin, 1993).

In accordance to KBSM, students must have ability and capability to creative and critical in thinking. Creative and critical thinking are classified as high order thinking based on Bloom's Taxonomy, this shown that simulation is highly appropriate to be apply in learning that has objective promote creative and critical thinking.
In order to realize this objective, teachers were promotes to practicing students' centered learning and acting as facilitator or moderator. Restrict by some problems such as rigid thinking and minds regarding contemporary approach, time and space constrain, added by lack of experience on this new approach had hampered the objective from achieved. Abd.Razak*et al.,* (1996) states that teachers in MoE schools still practicing traditional methods like direct and deductive approach lead to disabilities to achieve some objectives lined by KBSM. This rigid approach still can be found practicing in MoE schools till today even more that ten years had passed.

Conventional methods limit students' understanding and promote misconceptions. In contrast, contemporary methods were design to overcome conventional methods limitations. Noriah*et al.,* (2002) states traditional teaching method such as the talk and chalk technique, and classroom lecture, might only allow limited amount of information to flow from lecturers to students depending on the amount of knowledge acquired by lecturers. At the same time, no bilateral approach exists and it relies on linear fashion (Grasha, 1997).

For the above reasons, it was decided to develop a web based system capable of reduce learning difficulties and eliminate misconception using animation and simulation based on inquiry-based learning approach.

Rational Of Simulation

Multimedia offers multiple choices for delivering knowledge into students. Teachers are free to choose any mean of delivery they want, but, selection must base on rational justification and argument with consideration at objective in order to maximize the affect of multimedia. This research use simulation incorporation of inquiry-based learning approach because:

- Simulation able to provide users with hand-on and mind-on activities.
- Simulation possesses the essential elements of motivation in learning (Alessi and Trollip, 2001).
- Simulation interacts with more than one sense lead to positive stimulation (Duffy & Cunningham, 1996).
- Simulation highly compatible with constructivism, as it support scaffolding and allow teacher to act as moderator or facilitator (Alessi & Trollip, 2001).

Rational Of Implementing Inquiry-Based Learning Approach

Malaysian students encounter various problems when transiting from secondary to tertiary level of education. It is common if an excellent students from MoE secondary schools to achieve moderate or low CGPA in university either local or overseas. Similar problem involve students from MoE matriculation programs.

Students' achievement also low and faces inability to solve problems encounter in fields and something that is out of their text book scope. Hence, it was some of reasons why Malaysian graduates not easily accepted in multinational companies beside incompetency in English.

Chemistry students works with abstract condition with needs on high imagination. In order to train imagination, creativity, and critical thinking, students should be exposes to open exploration with combination of hand-on and mind-on activities.

Inquiry based learning approach was selected as strategy and approach in this research based on previous researches that shown inquiry based learning as:

- Inquiry based learning promotes development of students' higher level thinking order as well as their academic skills (Christopher et al., 2009b).
- Inquiry based learning train students' ability to become researchers and practicing lifelong learning (Christopher *et al.,* 2009a).
- Inquiry based learning enable students to connect macroscopic data, chemical equation and authentic application of chemistry through open ended exploratory experience which is more effective that experiments with closed outcomes (Annette, 2008). Ability to view the connection and interdependent in Chemistry Triangle reduce frequency of misconceptions and learning difficulties.
- Inquiry based learning increase students' motivation and interest during learning process take place (Annette, 2008).

Rational Of Subtopic Electrochemistry

This research selected Chemistry subject as it is a “queen of science”. Chemistry involves physics, mathematics, and additional mathematics. Ironically, those subjects do not involve chemistry in significant extent. Additionally, chemistry involves lots of abstracts concepts such as electrons, protons, orbitals, etc. This fundamental element in chemistry cannot be seen by naked eyes. Learning difficulties arise as learning in class room not connected to real world; in condition the knowledge develop and apply. Misconception was result of passive in learning and inability to imagine dynamic abstract concepts. This research selects electrochemistry as a discipline in research because of the following factors:

a. Chemistry curricula commonly incorporate many abstract concepts, which are central to further learning in both chemistry and other sciences (Taber, 2002).
b. Previous research shown that students encounter lot of misconception in electrochemistry topic.
c. One of the essential characteristics of chemistry is the constant interplay between the macroscopic and microscopic levels of thought, and it is this aspect of chemistry (and physics) learning that represents a significant challenge to novices (Bradley & Brand, 1985).

Research Importance

In Malaysia, after years of introduction of KBSM into MoE secondary schools, most teachers especially in regular daily schools still practicing traditional approach in teaching which relies on teacher center teaching process. In order to achieve status as developed country by 2020, Malaysian students should be train to think in creative and critical manner, exposes to open exploration and a great understanding regarding their respective field. These objectives are argues can be reach by using animation and simulation as they support inquiry-based learning open to exploration. Hence, the importances of this research are:

- The research investigate how simulation reduce learn difficulties (show students the abstract concept by visual representation and interaction) by promote hypothetical-deductive though.
- The research investigates how simulation eliminates or reduces misconceptions (by hand-on and mind-on activity: connect Chemistry Triangle).
- The research will show the need on students’ direct interaction with simulation to promote high order thinking (creative and critical).

- The research investigates relationship between students' ability and interaction with simulation. Finding could be use in developing future simulation for students centered learning.

In this research, simulation will be develop based on iterative and procedural type of simulation, but be class as iterative refer to its main function. The inquiry-discovery model use is Kolb's Experiential Learning Cycle.

Research Scope And Limitation

The research intended to develop web based simulation implementing inquiry-based learning approach. Simulation is class as iterative simulation and instructional strategies are scientific discovery learning and laboratory simulation.
Developed system will be test to intended sample to measure its efficiency from the aspect of students' achievement, degree of reduction of learning difficulties (increase level of hypothetical-deductive though) and elimination of misconception. At the same time, researcher observes students' interaction with simulation and makes suggestion for features of simulation that suitable for specific group of students. The research excludes factors such as computer literacy, interest in chemistry, learning style and any external factors affect students' learning. The research only involves educational computer simulation and this focus covers all aspects such as design, content, development etc.

Conclusion

Students' learning difficulties and misconceptions in physical science was cause by traditional classroom instruction, traditional laboratory and direct approach practicing by teachers. Students' disabilities to develop correct mind model also lead to these problems. This paper propose a study that setting forth the crucial need of designing and developing simulation system that implementing inquiry-based learning to reduce learning difficulties by exposes students to an environment that conducive for physical science, enhance understanding in abstract concepts, connect to real world situation and suit heterogeneous ability of students. Besides that, the proposed system should also eliminate misconceptions

by dynamic visual representation to ease the process of scientific model development by learners.

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