

Proceedings of The International Conference on Electrical Engineering and Informatics

ICEEI 2007

Institut Teknologi Bandung, Bandung, Indonesia
June 17 - 19, 2007



Organized by:
School of Electrical Engineering and Informatics (STEI)
Institut Teknologi Bandung, Indonesia



Co-Organized by:
Faculty of Information Science and Technology
Universiti Kebangsaan Malaysia, Malaysia



Sponsored by:
IEEE Indonesian Section Engineering in Medicine and Biology Society Chapter
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Indonesian Biomedical Engineering Society (IBES)

ISBN : 978-979-16338-0-2

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ISBN 978-979-16338-0-2

Development of VLab-Chem for Chemistry Subject Based on Constructivism-Cognitivism-Contextual Approach

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This paper is about development of virtual laboratory for chemistry subject (VLab-Chem). In this research, the term virtual laboratory is used to show the student that there are in a real laboratory when they done their experiment using computer. Student can interact with the material and apparatus, and also see the reaction in the experiment fully with animation and simulation. Discussion involved on theoretical framework modeling where it divided into two parts that is analysis, design, development and evaluation. For the second objective, researcher was view on constructivism- cognitivism -contextual lifecycle model. For the third objective, researcher also explained the laboratory architecture of development VLab-Chem. While designing the development of VLab-Chem, researcher has used approach in learning theory such as constructivism-cognitivism-contextual. Concept through learning-by-doing, contextual education, simulation, animation to create virtual based on learning, added in the VLab-Chem.

1. Introduction

Research in virtual laboratory is more than virtual learning approach. In this research, virtual learning environment used the animation and simulation in the form of 2D. Student can explore the virtual chemistry laboratory, do their experiment and get the output from that experiment. Students also need to keep their experiment information such as inference and observation in the electronic experiment report and worksheet as soon as the information recorded, student are allowed to edit and print the report.

For this research, simulation term is used to show the action of experiment done in the chemistry laboratory, focused on the aspects of exchanging color, precipitate, shining, dissolve, burning heat and etc. The virtual laboratory development with simulation approach to the laboratory apparatus and experiment makes user in a real laboratory (4). It also help user during educational long distance. There is a certain concept in virtual laboratory like *www* and learning by doing, which is using computer as a tool in doing experiment more fun and attractive.

Simulation is one of the computer programming in order the interaction among user and computer as a physical world scientific model, real world or theoretical system simulation is been used as part of learning plan whether in a tutorial as a learning strategy, learning equipment itself or as a based to achieve learning objectives(6).

2. Problem Statement

The result of interviewed with chemistry teacher, shows that the topic of salt is slightly difficult and also having many sub-topics. Learning in conventional approach often expose with the dangerous material. Besides that, early preparation should be done to prepare material and apparatus for experiment. Therefore it will result in higher cost and material experiment. A form five students lost his left body and disable to talk after having an accident during science experiment in his school (12). "The death of a French professor in a laboratory explosion at the National Institution of Higher Learning in Chemistry (ENSCMu) on 24 March, 2006 was a shocking reminder that research can be a risky business" (3).

Student who is integrate their technology in learning will search, analyze and evaluate information, become an informative user, solving problem and making decision with productivity material in a creative and effective way, become as a informative citizen, responsibility and contribute to the country development(7).

Teachers have to gone through syllabus in a hurry way that causes them to choose the important experiment only. In chemistry there are 2 topics more on reading that is chemical material in industry and chemical for user(5). The student are getting problem in learning process that needs them to do hypothesis, experiment designing, data integration and summary (1). The effectiveness of teaching and learning based on information technology and communication refer to the teacher in their integration of the aspect of pedagogy, physiology and technology and also the ability of student to access and learn from the serving material(9).

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3. Objective of Research

Result will give input to teachers and software design in the aspects; the suitable teaching for science software, technique or using software with the constructivism-cognitivism-contextual approach in learning and teaching.

Result also will input the school execution towards the virtual lab in the readiness of teacher requirement and the willingness of student to use the knowledge based on ICT.

- Besides that, research will give a chance to Education Legislation Principle to legislate the ICT in education and give the suitable accommodation for student in upper level and also to curriculum legislation to make the virtual lab and ICT in teaching and learning in lab.

4. Research Conceptual Mainframe

Research conception mainframe is used to development and effectiveness of virtual reality in delivering salt. The mainframe VLab-Chem Conceptual Research Mainframe is divided into 3 phases.

4.1 Problem Definition

This involved in interviewed between chemistry teacher and student to know the difficult topics in chemistry form 4. Analysis of document has been done due to the Education Certificate of Malaysia (SPM) performance report for the chemistry subject. Document analysis shows that overall performance through group of student in a higher group, middle and low. The information focused on higher and lower group for the discussed above.

Questionnaire has been distributed to the 14 chemistry teacher and 100 students of form 5 from 4 schools in Alor Gajah, Melaka, Malaysia district. The questionnaire is to defined difficulty level topics and sub topics for the chemistry form 4 subjects. The data from the questionnaire has been analyzed using statistical package SPSS version 11.0. Analysis showed that the difficulty of the topic salt resulted in higher average while salt quantitative as a sub topic mean=3.00.

4.2 Virtual Laboratory Development for Salt in Education to Strengthen Cognitive Skill

The development of virtual laboratory of salt was involved in development of instructional designing model (ID model). The development of the virtual laboratory will used the theory of constructive, cognitive and contextual by the cognitive domain in Bloom Taxonomy to strengthen cognitive skill for form 4 students. It will also join the conventional approach using information technology approach and exercise approach that is modules and exercise question.

Virtual laboratory for learning will follow the learning objectives as in chemistry subject curriculum. It will also focus on: -

- Contents to achieve the objective
- Result to be achieved and measured
- Delivery content strategy
- The ability of student to evaluate performance
- Student ability to refer and apply knowledge through the virtual laboratory

4.3 The Effectiveness Virtual Laboratory in Education to Strengthen Cognitive Skill

The effectiveness of the topics in salt in virtual laboratory will be study after the student used the lab itself. The aspect as shown below:

- Ability to access in various form of question regarding to the topics.
- Ability to used the topics itself to execute practical work in chemistry learning.

5. Theoretical Framework Model

Theoretical framework model had 3 structured profile that is Analysis and Design (I), Development (II) and Evaluation (III) for VLab-Chem. It is including research questioning and research hypothesis. To achieve the purpose of research, some main question and research hypothesis is designed as below:

- What is the methodology used in developing virtual lab for the chemistry subject (salt)?
- What is the instructional model design suitable in order to increase the cognitive skills based on virtual lab for chemistry subject (salt)?
- What is the chemistry virtual lab that is suitable for instructional design?
- Is there any differ in terms of achieving cognitive skills between students using virtual lab with student using conventional lab?
 - Hypothesis Mol 1 (Ho 1): No difference marks in pre test and post test for the control group in salt topic.
 - Hypothesis Mol 2 (Ho 2): No difference marks in pre test and post test for the experiment group in salt topic.
 - Hypothesis Mol 3 (Ho 3): No difference in achieving between students from experiment group using virtual lab based on constructivism - cognitivism - contextual approach and control group that using conventional lab.

VLab-Chem virtual laboratory include virtual lab module and learning module. Virtual lab module include personal guide, store (material and apparatus), books (glossary, map, equipment aid and material, experiment room (salt) and also laboratory map, whereby in learning module include experiment module, revision module, mind testing module, induction module and electronics experiment report module. This research is one of the case study involved only form 4 students from Sekolah

Menengah Kebangsaan Dato' Dol Said, Alor Gajah, Melaka, Malaysia. Research include chemistry subject under the salt topic based on recent chemistry curriculum by the Ministry of Education Malaysia.

Constructivism members found that student should learn in order to create construct, define and make their understanding in many ways based on experience and on-line relation with environment (2). Education is one of activity that been done by student by their self (10). By helping student in their integration with experience and new knowledge they already have, the activity should be in the context of needed requirement and in different perspective (2),(8).

Cognitivism theory refers to the process of thinking that happened to someone while in the process of learning. It relate with short time and long-time memory. While in learning, student created a cognitive structure in their memory. Every time student learn, they will used all its experience in learning and store all the experience in their memory until they want to used it, in order to help him in the learning process.

Based on previous research, in designing learning activity, cognitive structure of student should be taken (11). Cognitive theories figures, Brunner, Piaget and Papert focused on main concept that is how knowledge can be arranged and structured, the willingness of student to study, give value upon intuition and intellectual approach to achieve conclusion without following analytical steps and the important of motivation to study or having positive attitude in learning (11). Based on cognitive theory, some guidelines have been used in creating and evaluate learning based on computer (11).

6. Evaluation of The Effective Usage Based on Constructivisme-Cognitivisme-Contextual Approach

In this section, the effectiveness of VLab-Chem virtual laboratory and its overall performance is measured. The evaluation is been done among student who used the VLab-Chem virtual laboratory with the student using conventional learning approach.

VLab-Chem virtual laboratory will be test using English. Result based on the research case of form 4 student achievement of Sekolah Menengah Kebangsaan Dato' Dol Said, Alor Gajah, Melaka, Malaysia. Pre-test and post-test questionnaire will be used to evaluate student performance. 2 section in this question that is in section A, 20 objective questions and multiple choice while in section B, structure questions. Questions in section A will evaluate cognitive level involved knowledge, understanding, application and analysis. While questions in section B are involved higher level such as analysis, application, synthesis and evaluation.

6.1 Is there any difference in student achievement between student using VLab-Chem virtual laboratory and using traditional approach?

The partial research experiment has been done to the 2 groups of form 4 student at Sekolah Menengah Kebangsaan Dato' Dol Said, Alor Gajah, Melaka, Malaysia. Experiment (E) group has gone learning process of salt topic through VLab-Chem virtual laboratory based on constructivism-cognitivism-contextual approach. While Control(C) group learned the topic through the traditional approach. Evaluation done through marks given in the pre-test and post-test for both groups.

6.2 Descriptive analysis overall achievement for the salt

Result from the pre-test done, average mark for the control group is 14.10% while the experiment group is 13.53%. It shows the small difference about 0.57%. In the post-test, average mark to test student performance for the experiment group is 47.00% while control group is 29.23%. Meaning that average difference to test the students' performance between the 2 groups is 17.77%. Therefore it shows that average increasing performance for the experiment group is bigger than control group.

Majority student from the control group did not doing well in their post-test, therefore they cannot grab the minimum level of salt topic. While experiment group shown that achievement tabulation are average. It shows that VLab-Chem virtual laboratory with the constructivism-cognitivism-contextual approach help student in salt topic.

6.3 Statistical analysis for student achievement for the salt topic

To define the differentiate relation between marks in the pre-test and post-test, difference achievement for both groups, couple t-test has been used. Data has been analyzing using SPSS software version 12.0. Figure 1 Data analysis designing model used to test student achievement in the salt topic.

a. Hypothesis Mol 1 (Ho1) : No difference marks in pre-test and post-test for the control group in salt topic.

Paired t-test has been used to show the student achievement to define effect in higher level thinking skill for the experiment group. They have been gone the learning through VLab-Chem virtual laboratory. Result shows that t value =9.948, with the significant value for the both end, $p=0.000$. As the p value less than 0.05, statistically it show that there is increasing in mark achievement in pre-test and post-test in their higher level thinking skills. Meaning that mol hypothesis has been rejected.

Table 1. Coupled t-test in the pre-test and post-test for the control (C) group

Variables	Mean	Std.Dev.	N	error	t-value
Cpre	14.1000	7.81400	30	1.52129	-9.948
Cpost	29.2333	9.55450			

b. Hypothesis Mol 2 (Ho2) : No difference marks in pre test and post test for the experiment group in salt topic.

Result shows that t value =15.977, with the significant value for the both end, $p=0.000$. As the p value less than 0.05, statistically it show that there is increasing in mark achievement in pre-test and post-test in their higher level thinking skills. Meaning that mol hypothesis has been rejected. Attachment N2 shows the detail statistic.

Table 2. Coupled t-test in the pre-test and post-test for the experiment (E) group

Variables	Mean	Std.Dev.	N	error	t-value
Epre	13.5333	7.915220	30	2.09473	-15.977
Epost	47.0000	11.42290			

c. Hypothesis Mol 3 (Ho3) : No difference in achieving between students from experiment group using VLab-Chem virtual laboratory based on constructivism - cognitivism - contextual approach and control group that using conventional lab.

Comparison in achievement in the pre-test based on the set of question in the post-test for both groups using t-test. Result shows that average mark for the C group, mean=29.23333, while E group, mean=47.0000 with the t value, $t=7.892$, taking into consideration at the both end, $p=0.00$. It shows that a significant difference in higher level thinking skill for both groups. Meaning that nol hypothesis is been rejected. Experiment group gone the learning process through virtual lab VLab-Chem show the better achievement rather than control group, learning through conventional technique. Statistical detailed shown in N3 attachment.

Table 3. Coupled t-test in the post-test for the control (C) and experiment (E) group

Variables	Mean	Std.Dev.	N	error	t-value
Cpost	29.2333	11.42290	30	2.25127	7.892
Epost	47.0000	9.55450			

7. Conclusions

These researches try to use learning based on computer for the virtual laboratory in the chemistry subject (salt). The student or the teacher especially for the form 4 and 5 students will use it. The result will be analyze and compare with the already learning approach. Hopefully with this research, virtual laboratory could increase students and teachers understanding in this subject. In other word, educational level will be increase parallel with the

information technology. Therefore, learning based computer is build to increase the efficiency of student ability with the aid of multimedia.

This paperwork has been discussing the research methodology including VLab-Chem development methodology. Detail description through phases involved in the development. Through virtual lab methodology, constructivism-cognitivism-contextual life cycle for chemistry subject has been produced. In the VLab-Chem, one instructional model has been developed with the constructivism-cognitivism-contextual approach where model focused on science approach, learning sequence, holistic development, planning learning, and teaching and learning through interactive multimedia.

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