CAIMESTRY: DEVELOPMENT OF A COMPUTER AIDED INSTRUCTION ON CHEMISTRY FOR COLLEGE FRESHMEN STUDENTS

Aida A. Escorial, MIT
Department of Information Technology, Institute of Computer Studies,
Western Mindanao State University, Zamboanga City, 7000, Philippines
aida.aksah@gmail.com

Aloha May H. Ambe, MIT
Department of Information Technology, School of Computer Studies,
Mindanao State University – Iligan Institute of Technology, Iligan City, 9200, Philippines
alohamay.ambe@g.msuiit.edu.ph

ABSTRACT

The use of technologies has provided multiple pathways in learning where learners are provided with immense opportunities to engage in a variety of learning modalities, whether auditory, visual, kinaesthetic, or combinations of these. Chemistry subject is one of the subjects being taught in tertiary education. Accordingly, several studies showed that students fail to understand Chemistry due to the difficulties in comprehending theories and formulas since teaching the subject involves clear demonstrations and visualization especially in dealing with abstract models, figures and diagrams. Also, one of the useful parts of instruction in Chemistry is dealing with laboratory experiments. With this, a Computer-Aided Instruction (CAI) was implemented in this study that serves as a supplementary tool in teaching selected Chemistry topics to make the learning of the students more interactive by integrating virtual process in performing laboratory experiments, animation, graphics, sounds, mini games, and voice over. During the development process, interviews were conducted to the subject matter expert (SME) to determine the initial requirements of the CAI particularly on the manner of presenting the topics. In addition, survey was also made to the students to determine the user design preferences, learning styles, and their computer literacy. CAI has undergone series of iterations and testing particularly on the design and implementation specific to the needs of the learners and the recommendations of the subject matter expert. The results of assessment testing made showed that the CAI plays an important role in understanding the selected topics in teaching Chemistry subject where it provides an interactive way of learning particularly in performing virtual laboratory experiments. Moreover, the study showed that the use of CAI gives students the opportunity to learn the contents at their own capacity and speed and able to repeat the tasks if not understand by the learners.

KEYWORDS – Computer-Aided Instruction, Computer Assisted Instruction, Instructional Design, Chemistry

INTRODUCTION

Chemistry is a branch of science that deals with matter and its properties, structures, compositions, and the use of reactions to form a new substance [1]. The core goals of chemistry education are to engage students in different scientific knowledge in chemistry and its nature [2]. It involves different abstract concepts, figures, and diagrams [3]. Furthermore, in chemistry classrooms, students rarely understand that they are building and using models to explain phenomena [2].

Today's information and communication technologies can be applied to science education. The use of computers in teaching and learning has been an effective media in teaching subjects that deals with abstract concepts, figures and diagrams particularly in Chemistry [3]. It is the most popular and well known in educational settings. Computer-Assisted Instruction (CAI) plays a vital role in contemporary teaching and learning of science concepts. In addition, it is evident that for effective use of computers in science classroom, computer aided instruction materials need to be developed. Accordingly, computers can be used as a supplementary tool in order to reach to educational goals [4].

Currently, the faculty faced with a problem where the students are not receptive to learning Chemistry because accordingly, teaching chemistry subject should involve clear demonstrations, understanding, and visualization especially dealing with abstract concepts, illustrations, and models. Thus, there is a need to provide a tool that would

encourage learning among the students through a system that allows them to learn Chemistry in an interactive manner - a way that makes use of the advancements in information technology. This study aims on the development of a Computer –Aided Instruction (CAI) on selected Chemistry topics for College Freshmen students.

METHODOLOGY

The methodology used in the study was Spiral model with evolutionary prototyping where in the development process involves five (5) phases namely, Define, Design, Demonstrate, Develop, and Deliver as shown in the figure. below.

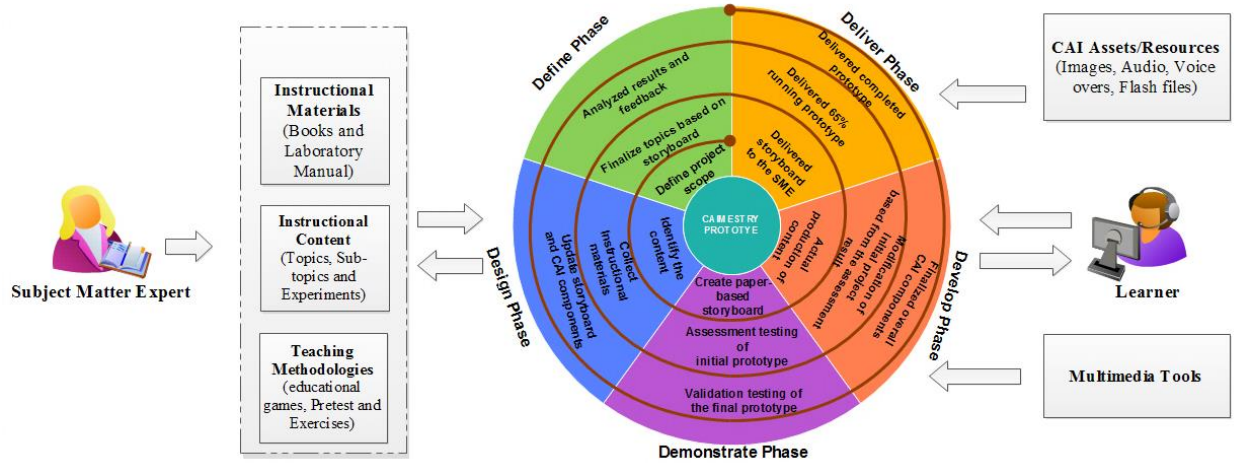

Figure 1 – CAIMESTRY Conceptual Framework

Figure 1 illustrates the conceptual framework paradigm of the CAIMESTRY. For every phase there were three iteration cycles involved. During the content analysis, the subject matter expert (SME) listed the topics to be included in the CAI, as well as the teaching methodologies to be included such as the manner of presenting the selected topics. Instructional materials such as the references and laboratory manuals were also given by the SME. These materials were incorporated in the development of CAI using the different multimedia tools. In learner analysis, the target learners gave their feedback and preferred design preferences, and their learning styles during the conducted surveys and interviews. Feedback and suggestions were also given by the learners during the testing of the initial prototype. During the development of CAI, it had undergone three iterations per phase with three different types of testing. In the First iteration, exploratory testing was done by the SME based on the presented paper-based storyboard. Changes and recommendations were made in the second iteration. During the second iteration, assessment testing was conducted on the initial running prototype by the SME as well as the target learners for user comments and suggestions. Modifications were incorporated on the implementation of the final prototype. Lastly, on the third iteration, the final prototype was delivered to the SME and potential learners for validation testing.

LITERATURE REVIEW

Integration of Computer-Aided Instruction to Education System

The use of computers in educational curriculum began in the 70's. Over the past three decades, educational researchers have investigated the effects on the use of computers in students' achievements and attitudes. Moreover, there are varieties of applications where computers are integrated in the academic curriculum such as Computer-Based Instruction (CBI), Computer-Based Education (CBE), and Computer-Assisted Instruction (CAI) which is also called as Computer-Aided Instruction. The CBE and CBI are generally implemented in a classroom setting where many facets of instructions are involved and can utilize a variety of computer technologies and applications. On the other hand, CAI is used when describing more specific applications that involve drill-and-practice, tutorials, simulations, or even games [5]. According to the study made by Barnea and Dori [6], the use of microcomputers to education in general, particularly in teaching science subjects, has increased the awareness of teachers and students that computers can be a productive tool in developing new methods and learning environments. Based on the empirical studies made by Cotton [7] the use of CAI produces higher achievement than the use of conventional instruction alone. In addition, the students learn instructional contents faster and they retain what they have learned than that of the conventional

instruction [8]. Moreover, numerous studies have been made and researchers have identified the importance of CAI in education. It has been found that CAI provides the learners to progress at their own paces, work individually, solve problems in a group, and allows computers to provide immediate feedback. Accordingly, CAI moves the learners' paces and usually does not move ahead until they have mastered the skill. Another importance of CAI includes assisting students' understanding of concepts, enhancing the students' motivation in exploring, investigating, creating and discovering principles [9].

Existing Computer Aided Instruction Systems on Chemistry Subject

Table 1– Comparison of existing Computer-Aided Instruction System

	Computer-Aided Instructional Materials (CAIM)	GCSE Chemistry	CCI Project	Creative Chemistry	Proposed CAImestry
MODEL					
Mental	✓	✓	✓	✓	✓
Expressed					
Consensus					
Scientific					
Teaching	✓	✓	✓	✓	✓
Curricular	✓	✓	✓	✓	✓
Hybrid	✓				
Pedagogy					
MODES OF REPRESENTATION					
Verbal	✓	✓	✓	✓	✓
Symbolic	✓	✓	✓	✓	✓
Visual	✓	✓	✓	✓	✓
Gestural					
Concrete					
Microscopic					
Macroscopic					✓

Based on the Table 1, all of the existing CAI systems used curricular, teaching and mental model in which personal representation of the phenomena of the student is formed. These models support the learning process of the student while using the system. However, the CAIM system used a Hybrid model to allow students interact with other groups during and after performing the experiments. In terms of the modes of representation, all of the existing systems used Verbal, Visual and Symbolic to represent the topics in CAI systems. Aside from verbal representation, usually in chemistry subjects, most of the topics are in a form of symbolic and visual illustrations since chemistry topics deal with abstract concepts, graphs, and diagrams.

In the development of Computer-Aided Instruction, Spiral model was used to combine both the design and prototyping in stages where design and development efforts were applied at each phase of CAI development. Moreover, Evolutionary Prototyping was integrated in the Spiral model where initial implementation was created, exposing this for user comments and feedback, and refining these through many stages until an adequate system had been

implemented. With this, multiple cycles of iterations were involved where suggested changes were incorporated in the final production of CAI components.

RESULTS AND DISCUSSION

The development of CAIMESTRY was implemented in three iterative cycles which resulted to the different features and interfaces of CAI as shown below.

Figure 2 – Sample Screenshot of CAIMESTRY

In this figure, it illustrates different environment of the developed CAI. This allows the learners to learn on the different laboratory apparatus being used during experimentation, table of elements, and simulation on selected laboratory experiments. The CAI is divided into three stages namely, Laboratory Apparatus, Periodic Table of Elements, and Laboratory Experiments. Also, the learners are provided Pre-test questions and mini games per lesson. In the Laboratory, learners are exposed to performing the selected experiments particularly on Evaporation and Filtration. Procedures and materials are provided to the learners.

Evaluation Results of the Stakeholders

The evaluation was conducted to three stakeholders; two chemistry teachers where one is the subject matter expert (SME), and the potential learners as the respondents. The respondents were given different set of questionnaires from the teachers. Furthermore, the results of the evaluation made by the target learners were analyzed to determine the improvements to be made for further development of the project. While the teachers' evaluation results were also analyzed to determine the instructional improvements of the design.

A. Evaluation of the Teachers

In the evaluation made, two of the chemistry teachers were asked to evaluate the use of CAI. Likert scale was used to measure the level of agreement or disagreement, positive or negative response towards a given statement. The questionnaire contains thirty (30) positive questions in terms of Instructional Content, Instructional Design, Management and Motivation, Ease of Use, and Technical Aspects to be rated in a ten-point scale, from 0 to 10.

First, in terms of Instructional Content, result shows that the objectives of the program are clearly defined, exercises are appropriate for lesson objectives, teacher can maximize learning with the courseware, the program is variability for repeated users, the level of difficulty is appropriate to the target learners, and the content of the lessons represent an important curricular topic. Second, in Instructional Design, the result shows that the content is sequenced appropriately, feedback is used appropriately, results are provided, students can control the rate, sequence, and level

of difficulty, and appropriately used of variety of displays, sound, color, and response modes. Third, in Management and Motivation, the subject matter expert in particular, rated 10, these are in terms of students move through the program contingent on progress, accurate and useful records of responses, provides entry level testing or pretest, used effectively in groups, holds student attentions, keeping the student on task, does not insult and demean students for every incorrect answers, program preserves student's privacy. Fourth, in terms of Ease of Use, the CAI got high points particularly in terms of the students can move forward, backwards, or to the menu, makes appropriate use of prompts, and students can re-enter program at previous point of exit. Lastly, in terms of Technical Aspects, The CAI got high points particularly on voice over, screen displays, graphics, and avoids unnecessary delays. Overall, it was found favorable to the teachers particularly on the manner of presenting the lessons, the simulation of laboratory experiments, the graphics, background music, and voice over.

B. Evaluation of the Target Users

During the evaluation of the target users towards the use of CAI, standard questionnaires were used. The questionnaire is divided into three categories namely Content, Design and Sounds, and Overall, with a total of sixteen (16) positive questions. Questions are to be rated in a five-point scale namely extremely satisfied (5), very satisfied (4), satisfied (3), neutral (2), and unsatisfied (1). For the evaluation of the target learners, Likert Scale was used to measure the respondent's attitudes towards a particular question whether agree or disagree, satisfied or unsatisfied. In analyzing Likert scale data, one of the measures that can be used is by getting the mean and the percentages of the given options. This method was helpful for the researchers to measure the satisfactory rating per category of the target learners. On the other hand, to measure the level of satisfaction of the target learners towards the use of CAI, graphical representations were used.

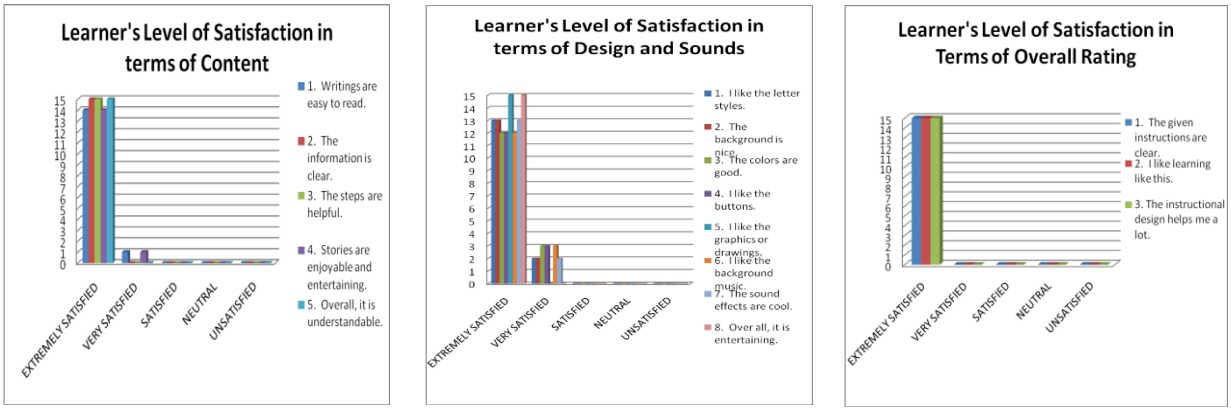

Figure 3 – Results of Learner's Level of Satisfaction in Content, Design and Sounds, and Overall Rating

Based on the figure on the level of satisfaction of the evaluation, the respondents have understood the lessons presented in the CAI, and to assess their satisfaction level in using the CAI, the result was favorable. Most of their comments were positive particularly on the design, sounds, and voice over, and CAI as a learning tool. Moreover, they found it very entertaining and enjoyable particularly on the animations and challenges given per stage including the simulation of selected laboratory experiments.

CONCLUSIONS

The development of the CAI in selected Chemistry topics provides a better way of presenting the lessons to the learners. Reviewing of related literatures were essential in the development of CAI to further improve the gap of other existing CAI systems related to the same subject matter. However, in this study, there are limited of experiments were provided to the target learners. In addition, different multimedia tools enabled the users to create different CAI interfaces. These tools allow the researcher to integrate sounds and voice over in the CAI system. With the used of different multimedia files, students concluded that the CAI provides interactivity between the system and its user. In terms of presenting the sequence of the topics, integration of educational games and pre-test questions motivated the learners to complete the challenge in every stage in the CAI. Most of the respondents found the CAI as entertaining, understandable, and useful. The results also showed that the CAI can be a supplementary tool in teaching and learning chemistry topics in a more interactive manner as reflected on the testing conducted. In the research methodology,

evolutionary prototyping was appropriate in this type of system development where the CAI was exposed to the subject matter expert and to the target learners for user comments and feedback. This enabled to meet the user requirements and research objectives.

REFERENCES

[1] Sirhan, G., Learning Difficulties in Chemistry: An Overview, 2007. [Online]. Available: http://crins08lerberg.wmwikis.net/file/view/sirhan.pdf. [Accessed: April 24, 2014].

[2] Aksela, M., "Supporting Meaningful Chemistry Learning and Higher-order Thinking through Computer-Assisted Inquiry: A Design Research Approach", 2005. [Online]. Available: http://ethesis.helsinki.fi/julkaisut/mat/kemia/vk/aksela/supporti.pdf]. [Accessed: September 2, 2013].

[3] Parmar, J., "A Study of Effectiveness of Computer Aided Instructional Material (CAIM) on Chemistry for Gujarati Medium Students of Standard XI", 2013. [Online]. Available: http://raijmr.com/wp-content/uploads/2013/05/15_56-61-Pri.-Jignesh-J.-Parmar.pdf. [Accessed: September 5, 2013].

[4] Cepni, S, Tas, E., Kose, S., "The effects of computer-assisted material on students cognitive levels, misconceptions and attitudes towards science", 2006. [Online]. Available: http://www.learntechlib.org/p/66580. [Accessed: September 23, 2013]

[5] Jeffs, T., Evmenova, A., Warren, S., Rider, R. (2006). An Action Research Study of Computer-Assisted Instruction within the First-Grade Classroom", 2006. [Online]. Available: http://www.atia.org/files/public/atobv3n1articleSIX.pdf. [Accessed: August 15, 2013].

[6] Barnea, N., " In-service Chemistry Teachers Training: Introducing Computer Technology as a Teaching Aid", 1993. [Online]. Available: http://www.mlrg.org/proc3pdfs/Barnea_Chemistry.pdf. [Accessed: August 15, 2013].

[7] Cotton, K., "Computer-Assisted Instruction. North West Regional Educational Laboratory, 1997. [Online]. Available: http://www.borg.com/~rparkany/PromOriginal/ETAP778/CAI.html. [Accessed: September 23, 2013].

[8] Yusuf, M., Afolabi, A., " Effects of Computer Assisted Instruction (CAI) on Secondary School Students' Performance in Biology", 2010. [Online] Available: http://www.tojet.net/articles/v9i1/918.pdf. [Accessed: August 12, 2013].

[9] Sowunmi, O., "Effect of Simulation Games and Computer Assisted Instruction on Performance in Primary Science", n.d. [Online]. Available: http://www.westeastinstitute.com/wp-content/uploads/2013/04/ORL13-162-Aladejana-Sobola-Full-Paper.pdf. [Accessed: September 5, 2013].

[10] Stefanowski, J., "Analysis of Questionnaires and Qualitative Data– Non-parametric Tests", 2013. [Online]. Available:http://www.cs.put.poznan.pl/jstefanowski/sed/DM12-nonparemetrictests.pdf. [Accessed: July 20, 2014].

[11] "Creative Chemistry". [Online]. http://www.creative-chemistry.org.uk/index.htm. [Accessed: May 07, 2014].

[12] Hansen, W., " The Spiral Model as a Tool for Evolutionary Acquisition", 2001. [Online] Available: http://nkhalid.seecs.nust.edu.pk/SE/software%20p.%20models%20readings/presentation%201.pdf. [Accessed: July 20, 2014].

[13] GCSE Chemistry. [Online] Available: http://www.cybersoftware.co.uk/gcsechemistry.html. [Accessed May 07, 2014].

ABOUT THE CONTRIBUTORS

Aida A. Escorial is a faculty member of the Information Technology Department, Institute of Computer Studies, Western Mindanao State University. She finished her Master in Information Technology from Mindanao State University – Iligan Institute of Technology, Iligan City, Philippines. She holds a Bachelor's degree in Computer Science major in Software Technology from Western Mindanao State University, Zamboanga City, Philippines.

Aloha May Hufana Ambe is a Ph.D. student with the Computer-Human Interaction discipline at Queensland University of Technology (QUT), Brisbane, Australia. Her research interests are co-design of the Internet of Things and other interactive technologies with older people. She holds a Bachelor's degree in Information Technology from Mindanao State University – Iligan Institute of Technology, Iligan City, Philippines and a Master's degree in Information Technology from Ateneo de Manila Unievrsity, Philippines.