COGNITIVE LOAD THEORY BASED MODEL IN MATHEMATICS SOFTWARE

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DISSERTATION SUBMITTED IN FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF COMPUTER SCIENCE

FACULTY OF COMPUTER SCIENCE AND INFORMATION TECHNOLOGY
UNIVERSITY OF MALAYA
KUALA LUMPUR

2011

UNIVERSITI MALAYA

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Registration/Matric No: WGA 060070

Name of Degree: MASTER OF COMPUTER SCIENCE

Title of Project Paper/Research Report/Dissertation/Thesis ("this Work"):

COGNITIVE LOAD THEORY BASED MODEL
IN MATHEMATICS SOFTWARE

Field of Study: MULTIMEDIA

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ABSTRACT

The Cognitive Load Theory (CLT) is extensively accepted by instructional designers since it offers theoretical foundations in designing guidelines for constructing. Instruction that effectively presents the learning in our working memory has an impact on our ability to store knowledge and skills in our long term memory. CLT suggests that the best instructional material facilitates by directing cognitive resources towards activities that are related to learning rather than toward preliminaries to learning. I applied the CLT to the design of the instructional courseware and discovered that CLT provides a sound baseline for the design of the learning instruction. Further, to effectively enhance courseware based instruction, the Graphical User Interface (GUI) and multimedia elements must be developed in considerations of CLT principles. The capacity of working memory is very limited, the CLT assumes that presenting different sources of information in the same modality, only visually easily caused split-attention effect, which leads to poor learning performance. To prevent this, a method recommended by CLT is to show information in different modalities for instance, auditory text plus visual displays. Current advances in the CLT research community have contributed significantly towards the instructional design of the interaction between information structures and human cognitive architecture. Moreover, the concept of element interactivity can be used to explain not only why some material is difficult to learn but also, why it can be so difficult to understand. The understanding becomes relevant when high element interactivity material with a naturally high cognitive load being learned.

ACKNOWLEDGEMENT

In my dissertation journey, many lives here supported me through this process. I would like to start off my words here by thinking Allah SWT, for His bless and guidance through this entire journey. I would like to thank all people who have helped and inspired me directly or indirectly during my master study. I would like to express my deep sincere gratitude to my supervisor, Mrs. Mas Idayu Sabri, Lecturer, Faculty of Computer Science and Communication, UM. Her wide knowledge and support have been of great value for me. Her understanding and personal guidance have provided a good basis for the present thesis. Deepest gratitude dedicated to all lecturers. I owe my most sincere gratitude and loving thanks to my wonderful husband, Mohamad Zamri for his patience and understanding during my educational pursuits and to my dearest kids Nurdayana Batrisya, Danish Irfan and Danish Firhan who inspired me to become a lifelong learner. To my beloved mother and father who continued to remind me that I could achieve this education step. I would like to extend my gratitude to my siblings, Eviyanti, Nuraimi, Nuraida, Irwan, Safwan, NurNabeela and Muhammad Hazwan for their support and encouragement. Thank you very much.

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CHAPTER 1

INTRODUCTION

1.0 Introduction

Advances in telecommunications technology have created new possibilities for learning across the boundaries of time and place (Bruner, J.S. 1979). What is now known about learning provides important guidelines for the uses of technology that can help students and teachers develop the competencies needed for the 21st century. Inappropriate use of technology can hinder learning – for example, if students spend most of their time picking fonts and colors for multimedia and reports instead of planning, writing and revising their ideas (Dunham, P.H. 1994).

Attempts to use technologies to enhance learning began with the effort of pioneers such as Atkinson and Suppes (Atkinson 1998). The computer technology trend will continue to accelerate. The view of technology is that its presence in schools will enhance student learning and achievement. Several groups have received the literature on technology and learning and concluded that it has a great potential to enhance achievement and teacher learning, but only if it is used appropriately (Bruner, J.S. 1979).

1.1 Project Details

1.1.1 The **aim** of the project is to integrate the pedagogical aspect with the technology in terms of the content, instructional design, interface and interactivity in learning Mathematics courseware development focusing on Quadratic Function for form four students.

1.1.2 Objectives:

1. To research how Cognitive Load Theory can support learning and understanding Mathematical concept.

2. To design and develop a prototype on Mathematics courseware based on the Cognitive Load Theory method in an interactive environment.

3. To evaluate the feasibility of supporting student learning using CLT based prototype.

1.1.3 Problem Statement

Coursewares nowadays focus too much on a multimedia content whilst overloading the information that can be absorbed by users. Currently it is estimated that 75% of today's industry are focusing on Mathematics due to the most important subject in school. Teaching and learning Mathematics in many Malaysian schools have been reported to be too teacher centered and that the students are not given enough opportunities to develop their own thinking skills (Goh, C. & Taib,Y. 2006). However, without *appropriate teaching method* used, this subject become very difficult to understand and comprehend. Many students are not able to comprehend what their Mathematics teachers teach because the content is taught with the intention of finishing the syllabus and preparing for the examinations.

There are many techniques that can be learnt to help students gain attention towards the subject. Traditional teaching approaches emphasizes more on how much the students can remember and less on how well the students can think and reason. Thus learning

becomes forced and seldom brings satisfaction to the students. In addition, Mathematics is traditionally thought of as memorization of formulae, the long and monotonous computation and the manipulation of numbers. It is also tradition that rules that the tools to computing and manipulating Mathematics are the pencil and paper. Finally it is also thought that the conventional way of delivering lessons is the chalk and talk method (Idris, N 2002).

The multimedia technology used in the learning courseware has the capability to combine and integrate various media like graphics, sound, text and animation making it is more meaningful and effective learning tool. Students generally have difficulty in understanding mathematical concepts because mathematics has not been introduced in a holistic approach. Mathematics has generally been introduced in isolation to the lives of the students as a whole, thus making learning Mathematics a meaningless as well as a dull experience. Realizing this problem, the research will need to identify a suitable theory to learn Mathematics in schools using the multimedia technology through the courseware. Hence, the researcher aware other potential subject but for this particular research, Mathematics will be used as the subject.

CLT states that learning can be maximized by ensuring that as much of a learners' working memory as possible is free to attend solely to encoding to-be-learned information (Sweller 2002). In the current software, student need to solve or practice many problems solving to learn because 'practice make perfect', but in this particular courseware, students learn by studying worked-examples. Problem solving is used to test if learning has been effective. The success of CLT in developing strategies and techniques which result in both reduced training times and enhanced performance is of

paramount importance to the education. For example, in CLT application courseware, it uses goal-free problem whilst in the current courseware it still use the conventional problems which specify the goal so that students 'know what they have to find'.

1.1.4 Project Significance

Mathematics courseware can be used as an additional reference material by students outside the classroom or beyond the school period. In addition, this courseware follows the school syllabus and therefore teachers would not have to worry about the content of this mathematics courseware.

The prototype cover on the topic of Quadratic Function and it is not only suitable for teachers to use it to enhance their teaching skills, but most importantly, it can be used by students for individualized and self paced learning. Hence, the courseware designed based on the Cognitive Load Theory method.

Cognitive Load Theory influence the design of the current multimedia-aided learning application:

- Multimedia-Aided Learning aim to provide learners with both rich set of learning resources and tools to help them navigate throughout the courseware. The Computer-Based Training is a method used in this particular research where based on CLT, evidence for learning by studying worked-example is known as ***worked-example effect and has been found to be useful*** in many domains such as physics, mathematics or programming to (Giller, S. & Barker, P. 2004),
- Mayer (1997) agreed that learning can be enhanced by ***displaying the graphic images and voice over concurrently with the text***. Cognitive Load methods can

be used for improving the instructional efficiency of ***interactive*** learning materials.

- As Mayer (1997) stated in his theory that the screen itself should be designed by the designer either with ***pictorial or text*** in order to make the courseware understandable.

This study enables greater participation from instructional or courseware designers and allows the designers to identify and improve areas of the courseware developed for the learners. In addition, this research can also serve as a basis for other courseware subjects such as science, physics, etc to implement the theory.

Furthermore, the results of the study aim to inform theory and practice that can be used to assists instructional or courseware designers to reduce the load caused by poor design of the learning materials. Therefore, the findings can be used to provide opportunity to make improvement to the courseware such as producing an easy to learn courseware and ensure the users are able to understand and process information to improve their performance, knowledge and skills.

Mathematics was chose as the research subject because this is one of the subject that need more memory load of human brain or thinking. According to Giller, S. & Barker, P. (2004), evidence for learning by studying worked-example is known as worked-example effect and has been found to be useful in many domains such as physics, mathematics or programming.

In this particular courseware development, the theory proposed by Mayer (1999) is used, that is the screen itself is designed either with pictorial or text in order to make the

content understandable.. Furthermore, by displaying the graphic images and voice over concurrently with the text, it can reduce the cognitive load of the users.

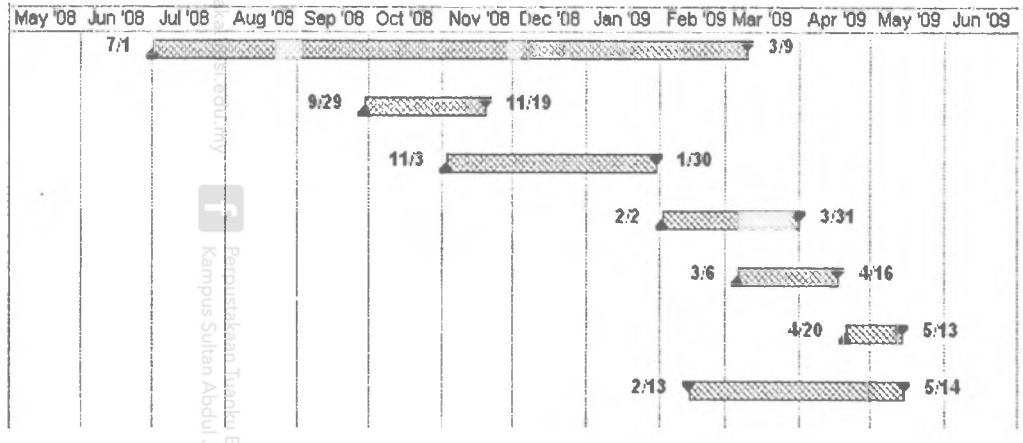
1.1.5 Project Scope

This Mathematics courseware mainly focuses on the higher secondary level, form four students to be exact. For this dissertation, the topic chosen is Quadratic Function. Quadratic Function is one of the important topics for Mathematics syllabus. In addition the subject requires a good teaching technique to attract attention from the students hence, minimize the working memory. After considering the importance of this topic, the Cognitive Load Theory (CLT) is proposed. The courseware is developed to see the effectiveness of the CLT. The courseware has incorporated interesting and colorful graphics as well as animation to enhance students' interest on the lesson taught.

The courseware adopts the perpetual navigational approach instead of sequential navigational approach, which helps students use the courseware more effectively as they are constantly aware where they are in the program. Moreover, the interactivity part of the system ensures that the student is actively participating in the learning process. The interactive approach to the exercises also means that students are able to obtain feedback from the system as to whether they are correct or otherwise, immediately. The system is able to show the correct method to solve a certain mathematical problem if he or she goes through the revision module. In addition at the end of the courseware, there will be a brief summary on the subtopics. The screen shot can be viewed in Chapter 4.

Table 1.1: Gantt Chart for CLT Based Model in Mathematics Software

	Task Name	Duration	Start	Finish
1	RESEARCH	180 days	Tue 7/1/08	Mon 3/9/09
2	ANALYSIS	38 days	Mon 9/29/08	Wed 11/19/08
3	DESIGN	65 days	Mon 11/3/08	Fri 1/30/09
4	IMPLEMENTATION	42 days	Mon 2/2/09	Tue 3/31/09
5	TESTING & EVALUATION	30 days	Fri 3/6/09	Thu 4/16/09
6	MODIFICATION	18 days	Mon 4/20/09	Wed 5/13/09
7	DOCUMENTATION	65 days	Fri 2/13/09	Thu 5/14/09



1.2 Project Schedule Descriptions

Analysis Phase: This is the foundation of all other phases in the design of the courseware. Data gathering took place at this stage. Pre-development test is conducted to get the response and feedback from the user regarding the effectiveness of having the Mathematics courseware for the students.

Design Phase: At this phase, the storyboard need to be designed based on the information gathered from the school syllabus that is form four secondary school. The outcome of this analysis phase creates blueprint for the instruction. This blueprint is called design document which covers the instructional strategies, content and creative treatment.

Development Phase: This phase uses the output of both the analysis and design phase. During this phase, I develop the instruction, the media to be used in the instruction and any supporting documentation based on the result from the data gathering pre-test results.

Implementation Phase: This phase refers to the actual delivery of the instruction. It should be classroom-based, lab-based, or computer-based. Macromedia Flash action script is a main programming language use to implement the courseware. Other supporting software includes Adobe Photoshop, Adobe illustrator, Sonic Foundry and Microsoft Visio.

Evaluation Phase: The evaluation phase measures how effectively the courseware can accomplished its stated goals. This stage proved that the use of multimedia elements

like graphics, animation did help the elementary school children in learning the concept of Quadratic Function topic.

Documentation Phase: This phase took place after all the data needed has been gathered for this project and analyzed.

1.3 Conclusion

Mathematics is an important subject but students still have difficulties in studying Mathematics. Therefore, educational design for effective learning and teaching environment is important to facilitate in learning Mathematics. Information Technology in the form of courseware can be used effectively to individualize instruction. The courseware has incorporated interesting and colorful graphics as well as animation to enhance students' interest on the lesson taught. In addition, this Mathematics courseware follow the syllabus, therefore, parents or students would not have to worry regarding the content itself. The scope of this research is form four students or higher secondary level school students. This courseware adapt the perpetual navigational approach which helps students use the courseware more effectively as they are constantly aware where they are in the program. This courseware uses the CLT method to see the effectiveness of learning the Mathematics subject focus on the topic on Quadratic Function. Before the prototype had been designed, pre-test questionnaires had been asked to the users to get the idea of designing the Cognitive Load Theory based model courseware. The findings of the data gathering helped a lot in terms of designing the courseware. The prototype of this courseware is developed in an interactive environment, therefore students can carry out the exercise given hence they can get the result on the level of their understanding towards the topic. This research conduct tests and evaluations on the courseware prototype based on the student's participation.