THE DESIGN AND DEVELOPMENT OF A MULTIMEDIA-ASSISTED MASTERY LEARNING COURSEWARE IN LEARNING OF CELLULAR RESPIRATION

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ABSTRACT. The study of cellular respiration is one of the most important in biology but often difficult subjects to teach at the high school, undergraduate or continuing education levels. This paper discusses the design and development of a Multimedia-assisted Mastery Learning Courseware (MMLC) by using a mastery learning strategy to enhance the learning of cellular respiration among Matriculation students. A courseware entitled "Cellular Respiration" was systematically developed using mastery learning elements to assist students who had difficulties in mastering and acquiring the concept of the topic. The model for the instructional system design and the a combined theory of instruction are introduced as the macro and micro stages of developing the courseware. The findings of this study show that the courseware is well designed in terms of using mastery learning elements which goes through a series of systematic testing stages. In turn, it is highly anticipated that the creation of the MMLC, would be a viable alternative approach so that all students could capture, in a richer and more meaningful manner, the concepts of cellular respiration.

Keywords: multimedia learning, learning biology, mastery learning

INTRODUCTION

Science education reform emphasised the need for computer technology to be integrated into learning, teaching, and assessment. In the past decade, the advent of Information and Communication Technology (ICT) made it pivotal to have an effective instructional design for better education in science (Dow, 2006). Since Malaysia is committed to developing and providing world-class educational systems, there was a need, in various fields, for an effective instructional medium which incorporates an appropriate learning environment. This study explains the design and development of a Multimedia-assisted Mastery Learning Courseware (MMLC), using a mastery learning strategy to enhance the learning of cellular respiration. It was reported that biology was a subject which contained many abstract concepts that was difficult to understand and affected students' learning outcomes. In particular, the cellular respiration was identified as a difficult topic in biology (Wandersee, Fisher & Moody; 2000). Unfortunately, this topic is the fundamental concept in cell biology which time and again students faces difficulties in understanding.

PROBLEM STATEMENT

A challenging goal was to improve student learning outcomes in basic science, especially biology courses, through the introduction of innovative teaching strategies. However, in the last few years, the advent of ICT eased the burden on the necessary resources for the teaching

and learning processes. The use of computers, as a ubiquitous teaching device, has become prevalent in the Malaysian education context. As such the use of computers, in combination with effective teaching strategies, has a tremendous potential in the teaching and learning processes.

Biology education delivers a truly broad scope which studies living organisms and how they interact with each other and their environment. Rice (2013) reported that biology was an abstract area which existed in unorganized structures and, therefore, it often results in students' learning difficulties. Complex processes and the use of technical terms made it difficult to learn some topics such as cellular respiration (Petro, 2008; Rice, 2013). The development of this courseware was aimed to help biology students at the Matriculation level in Malaysia. Before developing the MMLC, the researcher conducted a needs analysis by identifying the problem, the context, and the situation of biology education in Malaysia. A qualitative method, using unstructured interviews and observations were carried out to gather useful information to elicit the students' current problem in succeeding in biology and the need for any new instructional strategies. The researcher identified ten respondents, with various academic abilities, from two Matriculation colleges in order to participate in these interviews. The finding of this preliminary investigation confirmed that the current students faced problems in the learning of biology. The results revealed that there was a lack of good quality resources of learning materials for them to refer. Besides, limited time for revision and exploring each topic are deemed to be problems which needed to be solved in order to enhance their performance and understanding of biology.

COURSEWARE DESIGN AND DEVELOPMENT MODEL FOR MULTIMEDIA INSTRUCTION

The approach to designing the interactive multimedia courseware was based on Bloom's proposed mastery learning strategy, Mayer's Cognitive Theory of Multimedia Learning, Alessi and Trollip's instructional systems design, and Gagné's nine conditions of learning. All the models were appropriate for the development of this courseware.

Mastery Learning

Mastery learning plays an important role in fostering students' understanding of basic concepts of biology topics, and hence, in meeting the standards necessary in the learning of biology. It provides a systematic instruction which promotes the students' meaningful and efficient process of information (Figure 1).

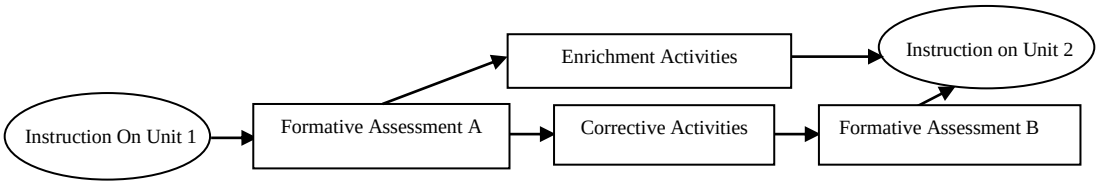

Figure 1. The Process of Instruction under Mastery Learning (Guskey, 1997)

The mastery learning method divides subject matter into units and each unit has a specific module to complete with predetermined objectives. In performing the unit tests, students should achieve mastery, typically 80%, before moving on to the following units. Students who do not achieve mastery, receive remedial instruction and students who achieve mastery, have the opportunity to participate in enrichment activities. With the use of the computers, mastery learning has a high potential to become an effective and extensive teaching and

learning tool (Guskey, 1987; Kulik et al., 1990; Fike et al., 2011). For each learning module, students are allowed to test and re-test until competency is achieved on each unit. This allows students to proceed at their own pace based upon their unique learning styles and capacities for learning. Each time when a student completes a test on a learning module, they are promptly informed of their performance and will receive immediate feedback on those items below the competency level. Accordingly, students who learn at a slower pace or have inadequate academic backgrounds are provided the opportunity to catch up with those students who have stronger backgrounds or learn at a more rapid pace. This tends to create an equalizing effect for students. In this study, all the instructional elements, in mastery learning strategy, are delivered via multimedia interactive tools.

Cognitive Theory of Multimedia Learning

The Cognitive Theory of Multimedia Learning (CTML) describes how people learn from words and pictures (Mayer, 2003). Figure 2 depicts the CTML which is intended to represent the human information processing system. Mayer's CTML encompasses three fundamental assumptions for multimedia design. These assumptions informs us how humans possess separate channels for processing visual and audio information, the reasons humans are limited in the amount of information that they can process in each channel at one time and engaging in active learning by attending to relevant incoming information besides organizing selected information into coherent mental representations, as well as integrating mental representation of other knowledge.

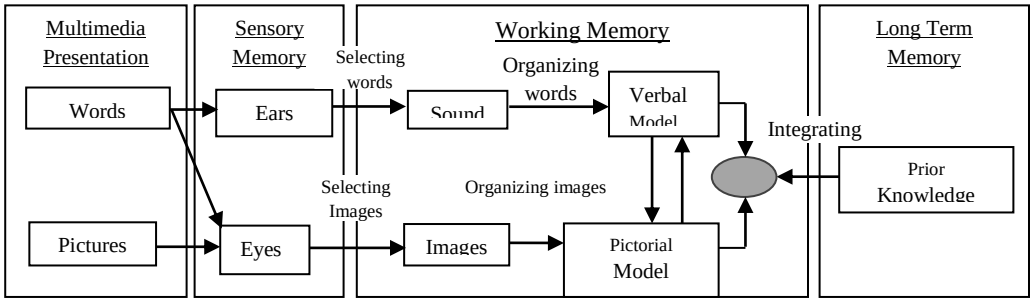

Figure 2. A cognitive theory of multimedia learning by Mayer (2003)

Referring to the third assumption, Mayer explains his philosophy for meaningful learning. According to Mayer, for meaningful learning to occur in a multimedia environment, the learners must engage in five cognitive processes. Firstly, the learner selects relevant words for processing in his/her verbal memory. Secondly, the learner selects relevant images for processing in his/her visual working memory. Thirdly, the learner organizes selected words into a verbal mental model. Then, the learner organizes selected images into a visual mental model and, lastly, the learner integrates verbal and visual representations. In line with CTML, Mayer (2009) proposed twelve research-based principles for the design of a multimedia application. The Multimedia Design Principles explain how students learn better from the multimedia elements. In this study, eight relevant principles were adopted in designing and developing the multimedia learning application. The eight principles are Multimedia Principle; Spatial Contiguity Principle; Temporal Contiguity Principle; Coherence Principle; Modality Principle; Redundancy Principle; Signalling Principle and Segmenting Principle.

Model of Instructional System Design

In addition to the CTML and in reference to the mastery learning model, it is considered to be closely aligned with the use of instructional objectives and the systematic design of instructional programs. Therefore, instructional design plays an important role in this matter.

The combination of systematic design, integration of mastery learning, and interactive multimedia might have a great impact on the teaching and learning of subjects, such as biology, whereby hierarchical and abstract knowledge are known requirements of the field.

A macro design stage, used in the development of this courseware, was adapted from Alessi and Trollip's instructional design model (Alessi & Trollip, 2001). This model is flexible and one can mould it according to individual needs and styles of work. On the whole, Alessi and Trollip (2001) created a comprehensive model for developing interactive materials. These have three attributes that are always present and three phases, each comprises a variety of issues to be addressed and actions to be taken. The three attributes are standards, on-going evaluation, and project management. The three phases are planning, design, and development. This means that, during the three phases in the design and development process, the courseware's designer and developer should bear in mind these three attributes constantly. Figure 3 illustrates how each component is linked to the others.

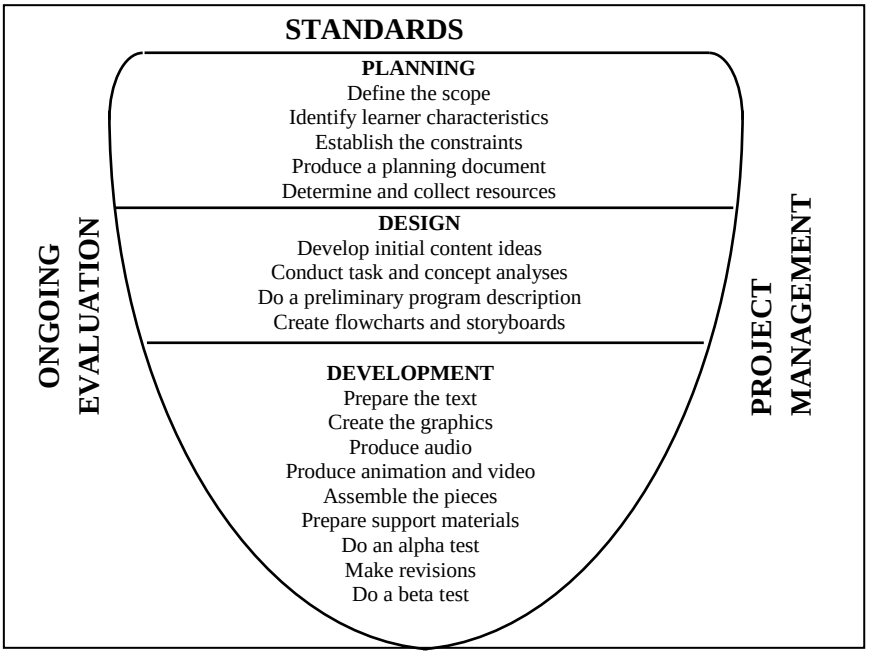

Figure 3. Model of instructional design by Alessi & Trollip (2001)

The planning phase ensures a thorough understanding of the whole project and assesses all the constraints (Alessi & Trollip, 2001). Generally, the researcher first determines the needs and the goals of the present courseware whereby the syllabus and the Matriculation biology text books were examined. The objectives were reviewed carefully since the knowledge's instructional level in the cellular respiration to be used in the courseware had to match the target learners' needs. The goals, of each module in the lessons, were stated at the beginning of each lesson. They included what the Matriculation students ought to know or be able to do after completing the lesson. The lessons correspond with the curriculum prepared in the matriculation examination. This is the basis for the objective and the structure-based tests to be prepared and developed.

The design phase deals with the activities of assembling the content and deciding on how it is to be treated from both an instructional and interactive perspective. This phase turns the proposed instructional product into a reality form. Ideas are turned into a first draft of the application and, finally, design documents are created. Furthermore, a conceptual model including theories, principles, and guidelines are used to engage people in such a way that learning takes place in an effective and efficient manner. In presenting the instruction

material, the researcher embedded Gagné's nine events of instruction as micro design strategies. Figure 4 explains the relationship between Gagné nine events of instruction and the component of mastery learning.

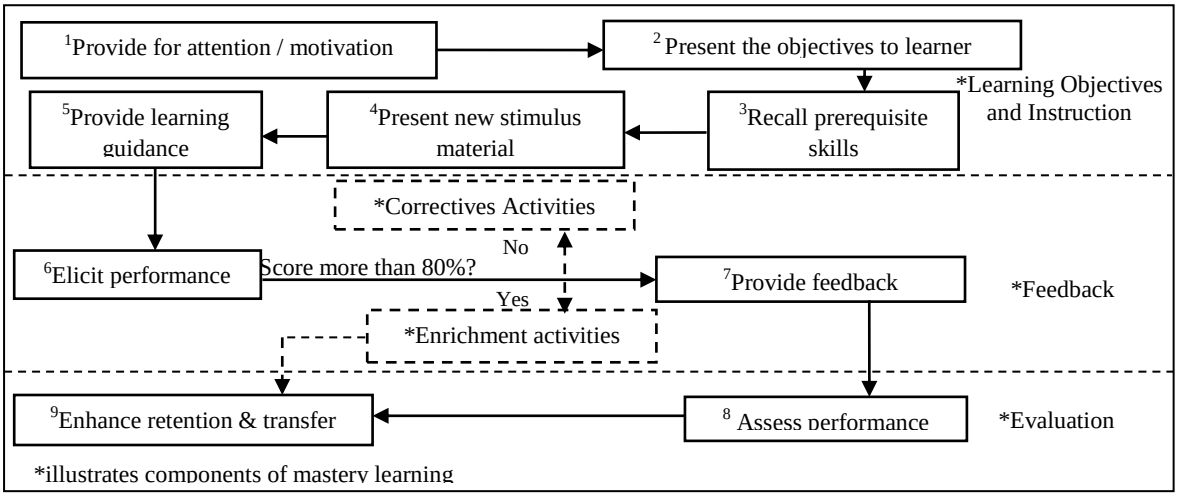

Figure 4. Gagné Nine events of Instruction and the Component of Mastery Learning

The development phase is the implementation of a prototype's design of a multimedia learning application. This includes the entire computer programming requirement to the whole application function. There are seven steps, involved in the development phase, which are: the production of the text; the production of the graphics and animations; the production of the audio and video; assembling all the pieces; preparing the support materials; doing an alpha test; making revisions and doing the beta test (Alessi & Trollip, 2001). In this research, an authoring software, namely Adobe Flash CS4, was used to design the courseware. Furthermore, the objects, in the form of graphics; animation; and sound were built as a knowledge base by using integrated tools like Micromedia Fireworks; Adobe Photoshop; and Sound Forge. This courseware incorporates video, media, sound, and animation which involved a great deal of bandwidth. Therefore, this courseware was purposely designed in a CD-ROM format, due to the capability of having sufficient memory to deliver instruction for such a biology topic.

Before the courseware was implemented, three content and three instructional design experts reviewed and evaluated it during alpha testing. Based on their evaluation, a few modifications and amendments were carried out. After all the revisions were made, a beta test was then conducted. The beta test involved target users carrying out a full test of the final product (Alessi & Trollip, 2001). It was a formal process with clear procedures about what to do and what to observe. The beta test was also carried out to serve as a useful trial run of the courseware. Meanwhile, it provided the researcher with information on any unexpected problems which might arise from the usage of the computer or the contents of the courseware. From the testing, it was found that the students could go through with the courseware without any glitches. Figure 5 and Figure 6 show two scenes of the multimedia interactive courseware for the cellular respiration topic.

CONCLUSION

This study provided helpful guidelines in terms of the design of useful templates for multimedia courseware using a mastery learning strategy. This courseware applied the main components of mastery learning in that (1) it specified clearly what was to be learnt and how it would be evaluated; (2) it allowed students to learn at their own pace in the instruction and,

then, to assess student progress and to provide appropriate feedback or remedies; and (3) testing the final learning criterion has been achieved. These templates could be adapted easily to other difficult biology topics and, therefore, save the development time in the future. In addition this study was useful, in terms of how the effective use of technology in education could help to overcome learning difficulties.

Figure 5. Biology teacher character interacting with the use

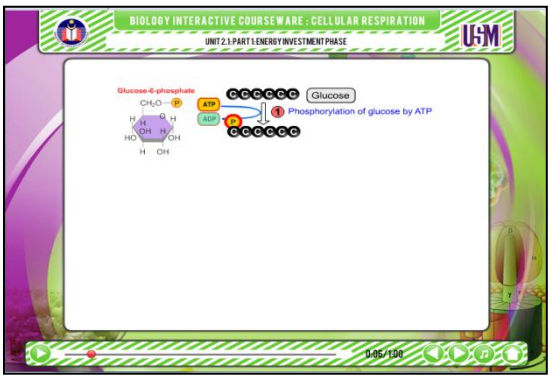

Figure 6. Example of instructional material using enhanced cues

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