The Development and Testing of Multimedia-assisted Mastery Learning Courseware with regard to the Learning of Cellular Respiration

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Abstract

This paper discusses the development and testing of Multimedia-assisted Mastery Learning Courseware (MMLC) with regard to the learning of cellular respiration. 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 design of the prototype is reported followed by the alpha test using usability evaluation. Beta testing was carried out after revisions were made based on expert comments. 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 conclusion, the MMLC is ready to be implemented in order to discover the effectiveness in terms of enhancing student’s performance with regard to learning cellular respiration.

1. Introduction

Recently, the advent of Information and Communication Technology (ICT) systems offers new capabilities for the delivery of instruction throughout the range of educational settings. At the moment, educators are exploring ways of providing flexible learning systems that will meet the ever-increasing demands of a complex and diverse student group. Moreover, many cases regarding student performance are reported, such as the difference between low achievers and high achievers (Guskey, 2007). To overcome this problem, various interventions have been suggested, including curriculum-based assessment (Hintze, Christ & Methe, 2006), tutoring (Sleeman & Brown, 1982), mastery learning (Bloom, 1984), formative assessment (Guskey, 2010) and so forth. Unfortunately, most of these interventions required additional resources such as teachers’ effort, workload and time. However, the advancement of ICT has eased the burden on the resources needed for teaching and learning processes. The employment of computers in teaching and learning is seen as the only way to maintain and promote the quality of instruction.

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2. Multimedia-assisted Mastery Learning Courseware in Biology

Biology is one of the subjects offered as part of the Matriculation science programme in Malaysia. This subject contains many abstract concepts that are difficult to understand. Students must be able to conceptualise and construct abstract concepts in biology in order to understand and make sense of them. Many students’ demonstrate common misconceptions concerning biology, including their understanding of topics such as respiration, photosynthesis, ecology, genetic, classification and the human circulatory system (Tekkaya, 2002). Furthermore complex processes and the use of technical terms such as in the topic of cellular respiration, make them difficult to learn (Patro, 2008). Hence, it is important to design a high quality instructional system to enhance the teaching and learning of difficult and abstract topics as part of the subject of biology.

The mastery learning method divides subject matter into units, each of which has a module with predetermined objectives which has to be completed. In doing unit tests, students should achieve mastery, typically 80%, before moving on to subsequent units. Students who do not achieve mastery receive remedial instruction, while students who achieve mastery have the opportunity to participate in enrichment activities. With the use of computers, mastery learning has a high potential to become an effective and extensive teaching and learning tool (Kulik et al., 1990; Fike et al., 2011) For each learning module, students are allowed to test and re-test until competency is achieved with regard to each unit. This allows students to proceed at their own pace based upon their unique learning styles and capacities for learning. Each time that students complete a test on a learning module, they are informed promptly of their performance, and receive immediate feedback on those items with regard to which they have not demonstrated competency. Accordingly, students who learn at a slower pace or who have an inadequate academic background, are provided with an opportunity to catch up with those students who have stronger backgrounds or who learn at a more rapid pace. This tends to create an equalizing effect for students. In this research, all the instructional elements as part of the mastery learning strategy, are delivered via multimedia interactive tools. With the advent of ICT as a teaching tool, and the availability of computer hardware in schools, the problem of applying mastery learning can be improved by using interactive courseware. Feedback activities could also be easily conducted using computers. In addition, in terms of recording the students’ performance, the technology could also reduce the time and effort required to implement the comprehensive interventions needed as part of the mastery learning process.

3. Methods

Learning courseware is a relatively recent application with regard to Computer Based Learning. This refers to the use of computers for the delivery of instruction involving an interactive approach. The researcher had developed courseware entitled "Cellular Respiration" to improve student’s performance and understanding with regard to this topic. The design of the courseware was based on a macro and micro design. Bloom’s mastery learning strategy (Bloom, 1984), Mayer’s Cognitive Theory of Multimedia Learning (Mayer, 2003) and Alessi and Trollip’s instructional design model (Alessi and Trollip, 2001) were used for the macro design. Gagné’s nine events of instruction (1985) was used for the micro design of the courseware. Motivational elements were incorporated into the courseware which was created based on Keller’ ARCS model of motivation. These were incorporated into the courseware which was created based on Gagné’s nine events of instruction. Keller’s model suggests strategies for increasing the motivation to learn. ARCS is an acronym for the four essential strategy components for motivating instruction, namely (1) Attention strategies for arousing and sustaining curiosity and interest, (2) Relevance strategies linked to learner’ needs, interests and intentions (3) Confidence strategies that help students develop a positive expectation for successful achievement, and (4) Satisfaction strategies that provide extrinsic and intrinsic reinforcement for effort. Attention involves the arousal of interest on the part of learners, the stimulation of an attitude of inquiry and the maintenance of attention. Relevance refers to tying instructions to the student’s personal
interest or goals. Confidence refers to the students’ expectations for success, while satisfaction refers to the process or results of the learning experience. In this research, an authoring software, Adobe Flash CS4, was used to design the courseware. Thumbnails that allow the development of the courseware through rapid prototyping were created by using this software. It allowed and illustrated the correct navigation within and among the modules. Furthermore, objects in the form of animations, graphics, texts and sounds were built as a knowledge base by using Micromedia Fireworks, Adobe Photoshop and Sound Forge. Figure 1 explained the flowchart of the courseware in general.

4. Testing and Revision

The final step of the development process was testing and revision. At first the researchers checked in advance with their two experts biology lecturers experienced in the Matriculation program to ensure that all the teaching content
be included in the courseware was correct, accurate and timely before the programming process. After the prototype was developed, the researchers conducted a comprehensive evaluation involving two phases. The first phase was the alpha testing while the second phase was the beta testing. These two phases were part of the assessment process as proposed by Alessi and Trollip (2001) to ensure the validity and reliability of the courseware being developed. Alpha testing involves the process of quality inspection involving content experts who undertook an evaluation of the courseware design. The evaluation process was done by each evaluator using a checklist evaluation of multimedia instructional materials. Three other biology teachers and two instructional design experts determined the validity of the content and evaluated the accuracy of the design and content presentation.

5.0 Results

5.1 Alpha testing

The alpha test results involving content experts indicated that the courseware met the learning needs associated with the cellular respiration topic. The contents of this courseware were accurate, complete and timely in terms of the Matriculation biology syllabus. Content experts also found that the audio quality used by the narrator was good and matched the quality of the animated video presentation that had been constructed. However, the content experts identified several minor errors in spelling such as acetyl-CoA, mitochondria and the symbols for oxygen (O₂) and carbon dioxide (CO₂). Some of the illustrations used such as in the Krebs cycle and the oxidative phosphorylation process was not clear and could be further improved. They also advised that the researchers used graphics relevant to the topic as a display montage and interface.

From the instructional design experts’ point of view, they were not satisfied with the selection of the background graphics for the montage display and the interface. In addition, the control button arrangement was also thought to be disorganized. The video animation did not have a complete set of control buttons (just a stop and a pause button). A video control button should be included so that students can control the speed of the video to match their individual needs. This is relevant to one aspect of multimedia design principles in the form of the principle of segments as proposed by Mayer (2009). The experts also suggested that the researchers should build a more uniform systematic control buttons set up below the display interface to clarify the teaching segments. However, they found that the design and programming of the mastery learning strategy was easy to follow. Using a biology teacher as a character is suitable since it acts as an important guide during the exploration of the courseware. Based on the feedback, a few modifications and amendments were carried out. All the modifications were carried out before the beta testing was done on students from the target population. Figure 2 shows prototype interface screen displays before and after a series of modifications were done.

Figure 2: Ordering interface display reconfigured to create a more systematic button control. Background graphic interface display changed to be more relevant to the topic and the video display screen enlarged.
4.2 Beta Testing

Beta testing follows revisions and utilises the full product for testing. The beta test was performed by the students with collaboration with the researcher. It was a formal process to determine the usefulness and the usability of the courseware, with clear procedures about what to do and what to observe. Usefulness refers to the extent that the courseware was useful in supporting the learning process. Meanwhile, usability was related to software technical operations which consisted of the interface and the interaction. The beta test was carried out to serve as a useful trial run of the courseware. Also, it provided the researcher with information with regard to any unexpected problems which may arise from the usage of the computer or the contents of the courseware. Indirectly, the researchers were able to identify any weaknesses or problems from the perspective of the students in relation to the use of the developed software. The researcher conducted two stages of beta testing namely; 1) one-to-one evaluation and 2) small group evaluation by students. One-to-one evaluation involved three target users with a range of biology academic achievement. Firstly, the researcher explained the procedure by informing the learners the reasons they were testing the courseware. During the evaluation session, the researcher observed the students going through the courseware. The researchers unobtrusively made note and observed the changes in behaviour, facial gestures, and the body language of the students. A short interview was conducted to get their reactions and feelings. From the testing, the three of them were satisfied with the courseware they explored. They responded positively especially from the aspect of language level, animated graphics and exercise provided. After the one-to-one evaluation, the researcher continued with the same method to a small group of students in a real classroom environment. Twenty seven students were brought to the computer laboratory to run the courseware and give feedback. This is regarded as a summative evaluation whereby a student’s approval is needed (Alessi & Trollip, 2001). Overall, it was found that the students were satisfied and could cope with the courseware without any problems. Figure 3, Figure 4, and Figure 5 show two scenes of the MMLC for the topic of cellular respiration.

Figure 3: The presented instruction material created through enhanced cues
5. Conclusion

Based on the evaluation carried out at all levels, it was found that the courseware was built to consider ideal characteristics such as interface design, audio quality, quality graphics, use of appropriate colours, good quality animation and ease of use. In addition, the results of the beta test and feedback from random interviews conducted with the students showed absence of programming errors. Overall, the students were satisfied with the content and operation of the courseware. It is hoped our MMLC will be a viable alternative approach for students leading to a significant increase in student achievement in terms of learning about cellular respiration. There are also positive possibilities to extend this courseware beyond biology with fruitful results.

References