A Conceptual Model for the Development of Enhanced Science Textbook Using Augmented Reality

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Abstract
This paper presents a conceptual model of enhanced science textbook using Augmented Reality (e-STAR). The conceptual model will be used as guidance in designing and developing the e-STAR prototype. Based on our preliminary investigation among form two students, it has been identified that students have the interest in learning science while in school. However, previous studies and statistics show that students lack the motivation to continually pursue their higher education and career related to science. Moreover, in Malaysia, there is a downward trend in student's achievement in Science subject. Science plays a very important role in student's future endeavors as well as for the development of a nation. Thus, this paper proposes a conceptual model of e-STAR as an effort to motivate students to be more interested in science through the use of Augmented Reality and interactive multimedia elements. The model incorporates several motivation theories and multimedia principles. This paper discusses on the theories and principles and how they will be applied in the design and development of the e-STAR prototype.

Keywords: Science learning, user-centred design, macro design strategies, micro design strategies

1. Introduction

Malaysia as a developing country has set a goal to achieve the developed nation status by the year 2020. As such, there will be a tremendous need for qualified workforces in science related fields (Nordin & Chin, 2010).They will play the roles as researchers, scientists, medical doctors, specialists, technologists, engineers, architects, designers and lecturers. This is in line with the 60:40 (60% science to 40% arts) policy introduced by the Ministry of Education (MOE). Furthermore, based on previous studies, there was a serious reduction (Osman, Iksan, &

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Halim, 2007) in the number of students majoring in science with only 29 percent in 2012 (Teh, 2013; Mohd Dom, 2012). This is far from the 60 per cent that has been targeted for science (Teh, 2013; Mohd Dom, 2012).

Nowadays, the younger generations are exposed to various forms of learning sources which are not only restricted to text and image alone. Instead, they are exposed to multimedia (MM) elements such as video, audio and 3D animation which can be accessed through the internet, CD/DVD and various others sources. Even though comprehensive science textbooks are provided in schools, supplementary learning materials are still required since some dynamic concepts are difficult to explain in the traditional method of teaching (Hwang, Tam, Lam, & Lam, 2012).

Based on our preliminary investigation (PI) among 108 Form two students, 96% of the students stated that they are interested in science. 60% of them referred to supplementary learning materials besides the main textbook which include printed books (50%) and online resources (65%). 70% of the students agreed that supplementary learning materials in the form of video and animation can increase their interest to learn science. 99% of them were able to understand a simple science concept through experiment. 87% of the students wanted the method of learning science to be reviewed. From the results, it can be concluded that the students preferred active learning environment where they can acquire knowledge and gain experience through the practical activities. It is clear that students are interested in science but at the same time they are also expecting some changes in the learning process.

Augmented Reality (AR) technology has its own unique touch in education which exposes a solitary and an active learning environment (Zainuddin, Zaman, & Ahmad, 2009). AR has proved its ability by partaking in and motivates students in the learning process for a long time (Wojciechowski & Cellary, 2013; Kerawalla, Luckin, Seljeflot, & Woolard, 2006). AR offers unique affordances, combining physical and virtual worlds with continuous and implicit user control of the point of view and interactivity (Wojciechowski & Cellary, 2013). This paper proposes a conceptual model of enhanced science textbook using Augmented Reality (e-STAR) based on motivation theories and Cognitive Theory of Multimedia Learning (CTML) principles. The purpose of this model is to provide guidelines on the design and development of an enhanced science textbook using Augmented Reality (AR) technology with the addition of MM elements. In the following sections, we describe the e-STAR conceptual model which includes discussion on the design for interaction, design for information and design for presentation.

2. The e-STAR Conceptual Model

A conceptual model comprises of identified theories, principles and hypothesized relationship between the measurements (Sekaran, 2003). It assists in determining the relationship among those measurements in enhancing the understanding of the research problem and solution (Zulkifli, Noor, Abu Bakar, Che Mat, & Ahmad, 2013; Dalle, 2010). The model is a huge asset in this study because through the use of the model, researcher, designer and developer are able to conceptualize a project from their perspective. Prior to the development of the model, all related theories and principles were identified and gathered from the literatures. The e-STAR conceptual model comprises of three prominent design components namely; design for interaction, design for information and design for presentation as shown in Figure 1. Figure 2 shows the design guidelines that have been followed in this study while Figure 3 shows the e-STAR conceptual model. The following sections discuss further on each of the design components of the e-STAR conceptual model and their implementation in the e-STAR prototype.

2.1 Design for Interaction: User-Centred Design (UCD)

Design for interaction adapts the User-Centred Design (UCD) as a guideline in order to depict the activity between the user and the e-STAR prototype. The ultimate purpose of implementing the UCD is to make the e-STAR prototype more comprehensive and able to motivate students to be more interested in science learning and continually pursue their higher education and career in science related areas. Besides that, the ARCS (Attention, Relevance, Confident and Satisfaction) model broadly utilized for learning motivation has also been incorporated to develop an effective e-STAR prototype. According to Keller (2008), ARCS model is able to provide sustainable motivation in a learning process. Moreover, ARCS is among the most effective and useful model to be applied in the learning process (Noor, Zulkifli, Yusoff & Siraj, 2011; Huang, Diefes-Dux, Imbrie, 2006).

Firstly, the Attention factor refers to gaining the student's attention and maintains their engagement in science (Keller, 2008). Secondly, the Relevance factor relates to students' experiences and needs (Keller, 2008). Thirdly, the Confidence factor incorporates students' feelings and expectancy for success (Keller, 2008). Finally, the Satisfaction factor includes strategies that help learners to establish positive feelings about their learning experiences and build the students' sense of reward and achievement (Keller, 2008). The ARCS Model is the most widely accepted models to be used in learning (Huang et al., 2006; Hu, 2008). It provides the motivational design, development and evaluation strategies that have been adapted in a variety of computer-based learning materials and instructional technologies. Table 1 describes the factors and strategies of the ARCS model in increasing students' motivation for science learning.

Motivation is an act which encourages someone to do some action (Guay, Chanal, Ratelle, Marsh, Larose, & Boivin, 2010). Motivation is salient for every individual, especially for students. In a learning environment, motivation deals with the problem of setting up conditions so that the learners will perform the best of their abilities in academic (Guay et al., 2010). Hence, in this study intrinsic motivation was adapted to intrinsically motivate students without any extrinsic reward or separable outcome (Ryan & Deci, 2000). The first-hand experience and the knowledge gained from the learning process cultivate the confidence and motivate the user to perform well in the learning process especially in science learning (Kerawalla et al., 2006).

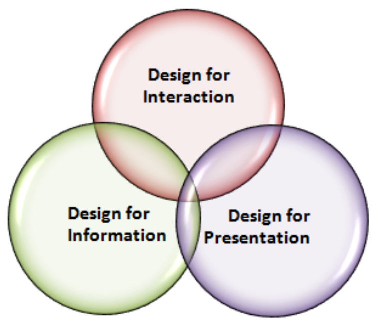


Figure 1. The e-STAR Design and Development Components

Figure 2. Design Guidelines for This Study

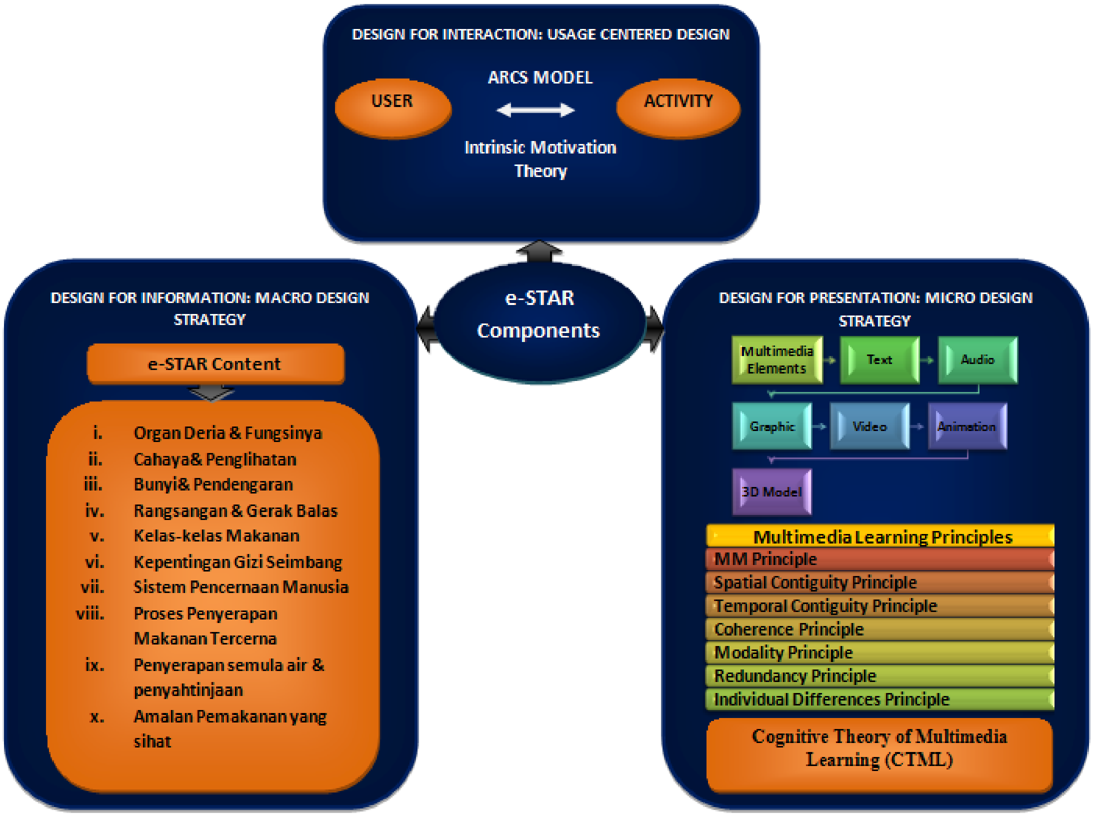


Figure 3. The e-STAR Conceptual Model

2.2 Design for Information: Macro Design Strategies

Designing the information is one of the crucial parts in a prototype development. The design information provided to the users must be detail, complete and valid in order to meet the objectives. Thus, the content itself is a major part of the conceptual model. The e-STAR prototype covers two chapters from the form two science textbook which entirely comprises of ten sub-topics. All the contents are derived from form two science textbook provided by the MOE and also from various academic sources suggested by the content expert (teacher).

The titles of the two chapters of the form two science textbook are; “The World through Our Senses” and “Nutrition”. The sub-topics for the first chapter include; i) Sensory organs and functions, ii) Light and vision, iii) Sound and hearing and iv) Stimulus and response. While the sub-topics for the second chapter include; i) Classes of food, ii) Importance of balanced nutrition, iii) Human digestive system, iv) The process of absorption of digested food, v) Reabsorption of water and bowel movements and vi) Healthy eating practices. Macro design strategies were applied to restructure and organize the information since macro design strategies assist in conveying information accurately and efficiently (Salam, 2010).

Table 1. ARCS Model's Factors and Strategies (Huang et al., 2006)

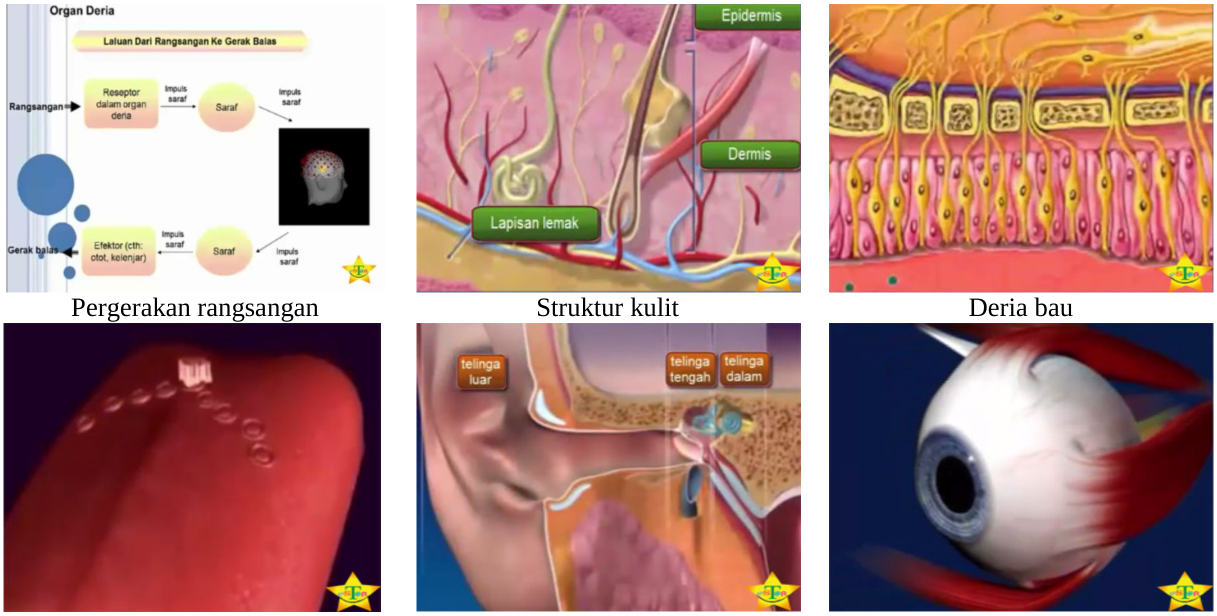
Factor	Description	Strategies
Attention	Student's attention and curiosity need to be aroused and sustained	**Perceptual Arousal:** Using novel, surprising, incongruous events to gain and maintain the student's attention level. **Inquiry Arousal:** Stimulating information seeking by questioning the students **Variability:** Providing varieties in elements to maintain students' motivation.
Relevance	Accomplishing the goals of learning	**Familiarity:** Facilitate the language and provide related examples. **Goal Orientation:** Provide statements or examples that are related to the objectives and goals. **Motivational Strategies:** Arranging the learning strategies related to the student's motive.
Confidence	Students need to feel the confidence, enjoy and success after completing the tasks	**Learning Requirement:** Provide students the probability of success by presenting performance requirements or evaluations. **Success Opportunities:** Provide challenge levels that allow meaningful success experience under both learning and performance conditions. **Personal Control:** Provide feedbacks in supporting the success.
Satisfaction	Satisfaction comes when students are allowed to practice by using the new knowledge which then leads to positive outcomes to the attitudes.	**Natural Consequences:** Provide opportunities to use new knowledge. **Positive Consequences:** Provide feedback and reinforcements that will sustain the desired behavior. **Equity:** Maintaining the consistent standards and consequences for task accomplishment.

2.2.1 The e- STAR Contents

The content of the prototype plays a vital role in this study and it must be comprehensive, fulfils the requirements set by the MOE and suitable for form two science learning. The content must be accurate and simple to learn and understand for that age group of students. Figure 4 shows a sample of the proposed content that has been applied in the e-STAR prototype.

2.3 Design for Presentation: Micro Design Strategies

Presentation is the medium to convey the e-STAR content to the user. It involves methods of presenting the content in the e-STAR prototype. In order to present the science content efficiently, the micro design strategies were adapted. Furthermore, the content of the prototype which consists of multimedia elements including text, audio, video, image, animation and 3D models need to be presented to the users by following certain principles and theory. Cognitive Theory of Multimedia Learning (CTML) has been applied in the presentation design. CTML states that multimedia learning occurs when the learner is able to build the mental representation through the use of text and images. Basically, the human brain does not interpret words, pictures and auditory information in a mutually exclusive fashion, but these elements are selected and organized dynamically to produce a logical model of presentation (Mayer, 2001). CTML explains the human behaviour by understanding their thought processes (Mayer, 2001; Mayer, 2002). According to Mayer & Moreno (1998) and Mayer (2003), CTML is based on three core assumptions, namely; dual channels (auditory and visual) for processing information and limited capacity of both channels. Last but not least, an active process of filtering, selecting, organizing and integrating information. The cooperation between MM elements in a learning process might improve the learner's long-term memory in storing information and knowledge. Mayer (2001) has identified seven principles of nature and effect of MM presentation design to the learners. Those are MM Principle, Spatial Contiguity Principle, Temporal Contiguity Principle, Coherence Principle, Modality Principle, Redundancy Principle, and Individual Differences Principles. Further explanations regarding each of the MM learning principles are as follows.



Pergerakan rangsangan | Struktur kulit | Deria bau

Deria rasa | Deria pendengaran | Deria penglihatan

Figure 4. Samples of e-STAR contents for sensory organs and functions

2.3.1 MM Principle

MM principle stated that when an image adds to a word rather the word stand alone, it is able to enhance the learning process. Combination between words and pictures convey the information more accurately and effectively. The e-STAR prototype provides proper images and words which assist the learner to understand the presented content (Noor et al., 2011).

2.3.2 Spatial Contiguity Principle

A near placement of corresponding words and pictures is better understood rather than far from each other on the page or screen (Mayer, 2001). The graphic is added with image and word, in order to enhance the understanding. Besides that, the static image presented with the explanation of the process and this enable the learner to easily understand the actual meaning of the process.

2.3.3 Temporal Contiguity Principle

Temporal contiguity principle claims that the simultaneously presentation of words and pictures is better than sequential presentation (Noor et al., 2011). In the e-STAR prototype, words and images are presented together with some movement which allow the user to build the mental connection between verbal (word) and pictorial (image).

2.3.4 Coherence Principle

The coherence principle stated that a learning process could be effective even the image, word and sound are excluded. Therefore, the e-STAR prototype avoided seemingly interesting words, pictures and sounds that were not relevant to the main message. It has narrowed the information presentations and the information is presented without any information overflow and in an attractive and interactive ways. The use of this principle facilitates learners, and promises a better understanding of user. As shown in Figure 5, only important points in a table format were presented without any additional images or description.

2.3.5 Modality Principle

Animation and narration is better at learning than from animation and on screen text whereby the learners learn better when words in multimedia presentation are presented as spoken text rather than printed text (Mayer, 2001). The e-STAR prototype implemented this principle for human sensory organs where the content presented with animation and narration.

2.3.6 Redundancy Principle

The redundancy principle is about the learning from animation, narration, and on-screen text. It avoids the visual channel becoming overloaded when on-screen-text and graphics are both visually presented (as animation and text). The use of narration and words can enhance learners' understanding since both utilize verbal and auditory channels.

Figure 5. Example of Coherence Principle in the e-STAR prototype

2.4 Conclusion

The continuous decline in the number of students pursuing in science related studies and careers is very disturbing. If no proper action is being taken by the authority, in the long run, it will have a negative impact on the country especially when we are targeting to be a developed nation by 2020. This paper provides an overview on the conceptual model of enhanced science textbook using Augmented Reality (e-STAR). The model which has been developed based on theories and principles was successfully used as guidelines in the design and development of the e-STAR prototype. The main intention of the prototype is to motivate students to be interested in science learning. As we are living in the digital era, the privilege should be acknowledged and applied especially in science learning domain. We hope that the e-STAR conceptual model can be used by applications developers in designing and developing more interesting and effective science learning materials that can greatly enhance the interest and motivation of students towards science learning in Malaysia.

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