An Augmented Reality System for Biology Science Education in Malaysia

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Abstract— **This paper presents an educational application for Form 4 Biology Science in Malaysian secondary schools using Augmented Reality (AR) technology, includes topics of mitosis, meiosis, respiration and their systematic relations. Worth mention is knowledge is a whole in which no part is really isolated but more or less systematically related to others. Knowing regularities is essential for having a concept at students' disposal as well as for object perception. An implicit understanding of regularities is a precondition of object perception. Having a concept means being able to assert that something, such as a specific attribute, a rule or a function, applies to all the objects of the same kind. These lessons are presented in dedicated stereoscopic and photo-realistic views, thus facilitating students in noticing, memorizing and understanding Biology concepts. Also, it allows students individualized interaction while enabling social communication, given thinking is but epistemic in its nature and that its organization has both individual and social dimensions. AR technology introduces a new type of automated applications and to enhance the effectiveness and attractiveness of learning environment for the students in a real world scenario. This AR study emphasizes on merging computer vision, image processing and computer graphics to form a new Human-Computer Interaction (HCI) paradigm.**

Keywords — Augmented Reality, virtual reality, education and training.

I. INTRODUCTION

The purpose of this study is to design and construct an Augmented Technology system (aka ATTech System) for educational purpose in learning Form 4 Biology in Malaysian secondary schools using markers as pointing devices. The Form 4 Biology units covered in this system include mitosis, meiosis, and respiration. This is an ongoing long-term study which has a goal to enhance students' perception and understanding about the complex process and phenomenon in Biology. Unlike VR system that aims to replace the perception of the world with an artificial one, this ATTech system provides a better means to make students learn in an interactive learning environment and acquire the cognitive and metacognitive skills for better "transfer" of learning. "Transfer" can be improved by helping students become aware and actively monitor their performance in understanding or comprehension. Creating suitable representation of the learning process in a rich context using AR interfaces allows the students to promote reflection of the metacognitive processes, where the students could see the real world as well as the virtual imagery, augmenting the real world with additional information. Worth mention is that human mental representation is an activation of knowledge and background knowledge provoked by a percept or sign in context of action.

Put differently, a phenomenon of being aware of something that is not actually present, as in the case of experiencing smoke activates the insight that whenever there is some smoke then there also might be some fire as its cause. This study also aims to introduce the students about the concept of optimal learning in the sense of optimal use of resources in AR technology. Moreover, we also aim to lead the way to improve education reliability, safety and quality in using AR technology in Malaysia.

II. BACKGROUND

A. AR as an Educational Tool

The use of new technologies and techniques such as multimedia and virtual reality in education has been increased tremendously and became more common in the new century. The new technology, AR even though has been well developed in overseas countries but it is still in its budding level in Malaysia. Therefore, its applications in education need to be explored even more often in order to show the effectiveness of the technology in teaching and learning in Malaysian schools.

It is an essential social need for educational change by implementing innovative educational practice with the usage of computer technology [1]. Based on the evaluation study on implementing AR learning system in school which carried out by Balog, Pribeanu, and Iordache [2], it strongly suggests that the AR learning system shows educational value which makes the learning environment more attractive, stimulating and exciting for students. The students enjoy the interactive learning manner, and feel like playing computer games when doing exercises using AR system.

B. An Example of Using AR in Education

There are tremendous of studies use AR technology in education. Figure 1 shows the AR education system, "MagicBook", developed by Billinghurst [3]. The "MagicBook" interface supports new forms of educational experience and it is a smart application to encourage children to read. It uses a normal book as the main interface object as students can turn the pages of the book as normal practice. What makes it more interesting and exciting is the 3D objects and animation, which allows vivid visualization in the learning process compared to traditional way of learning, whereby printed books only provide texts and static images.

Fig. 1. 3D virtual models appear out of the pages from "MagicBook"

Shelton and Hedley [6] evaluate the effectiveness of a group of undergraduate Geography students who use AR system to learn the sun-earth relationship. The study reports the students' misunderstanding about the concepts of sun-earth relationship is reduced after exposure to AR exercise. Moreover, their study also shows a significant overall improvement in students' understanding. Figure 2 shows the AR exercise on sun-earth relationship obtained from Shelton and Hedley's study.
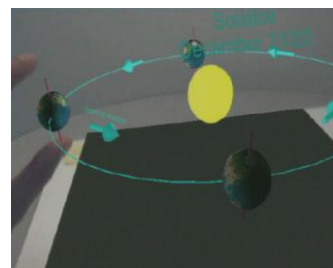

Fig. 2. Rotation/revolution, solstice/equinox, and seasonal variation of light and temperature about sun-earth relationship

Zhou et. al. [8] create a new way of 3D story telling method (Magic Story Cube) using AR technology. The "Magic Story Cube" is a tangible AR interactive interface for storytelling using physical cube, that makes story telling methods becomes more interactive and intuitive, from the HCI paradigm. Figure 3 shows the story telling method via "Magic Story Cube".

Fig. 3. Interaction with the "Magic Story Cube" to tell the story of "Noah's Ark"

Juan, Beatrice, and Cano [4] present an AR system for learning the interior of the human body. The study shows that children enjoy learning the system, either by using HMD or a typical PC-based monitor. Figure 4 shows the AR system of one of the human internal organs in the study.

Fig. 4. Students' hands and intestine are visible in AR Human Body system

There is a study carried out on AR education system in learning human digestive system. Vilkoniene [7] reports that students show significant improvements while completing some tasks in understanding of human digestive system after learning using AR technology. The studies mentioned above show that AR technology plays an important role in education, especially to assist students to comprehend knowledge that involves complex concepts and phenomena. AR becomes a new innovative way and essential for having a concept at students' disposal as well as for object perception in teaching and learning methods, especially in scientific subjects.

C. Value of Employing AR in Education

Since AR technology can provide better visualization on teaching and learning for education, therefore, the needs of using AR in education is encouraging. It allows students to utilize the data appropriately in many ways without suffering from the real consequences of human errors as well as developing new knowledge, skills, and attitudes. This provides opportunities to students for making mistakes, taking risks, and being adventurous. Thus, students can see the consequences of those actions without suffering from mistakes but instead learning more from mistakes [5].

III. OBJECTIVES

The objective of this study is to design and construct an Augmented Technology system for educational purpose in learning Form 4 Biology in Malaysian secondary schools using markers as pointing devices. The Form 4 Biology units covered in this system include mitosis, meiosis, and respiration. This is an ongoing long-term study which the goal is to enhance a person's perception and understanding about the complex process and phenomenon in Biology. Unlike Virtual Reality system that aims to replace the perception of the world with an artificial one, this ATTech system provides a better means to make students learn in an interactive learning environment and acquire the cognitive and metacognitive skills for better "transfer" of learning. "Transfer" can be improved by helping students become aware and actively monitor their performance in understanding or comprehension. Creating suitable representation of the learning process in a rich context using AR interfaces allows the students to promote reflection of the metacognitive processes, where the students could see the real world as well as the virtual imagery, augmenting the real world with additional information. This study introduces the students about the concept of optimal learning in the sense of optimal use of resources in AR technology. Moreover, we also aim to

lead the way to improve education reliability, safety and quality in using AR technology in Malaysia.

IV. OUR APPROACH AND SYSTEM

Our approach is centered on the students' needs in knowledge regularities. Knowledge is a whole in which no part is really isolated but more or less systematically related to others. Knowing regularities is essential for having a concept at learner's disposal as well as for object perception. An implicit understanding of regularities is a precondition of object perception. Having a concept means being able to assert that something, such as a specific attribute, a rule or a function, applies to all the objects of the same kind.

We create scenarios to explain aerobic and anaerobic respiration by providing a short augmented video or 3D storytelling to allow understanding of students, such as when will these types respiration occur under certain circumstances. Furthermore, we have as well created a "virtual teacher" as the complementary object to tell the scenario to the students so that they are more aware of what is going on with the phenomenon.

For example, ATTech system provides text and audio explanation, especially on the AR exercises. It allows the students to visualize the complex process and phenomenon of Form 4 Biology syllabus. In this scenario, students are prompted with the audio instruction to interact with the exercises via mouse clicks. ATTech also provides feedbacks to students as a way to communicate whether the exercises are completed correctly or wrongly.

Figure 5 shows the partial of reproduction and growth process that presented using ATTech system.
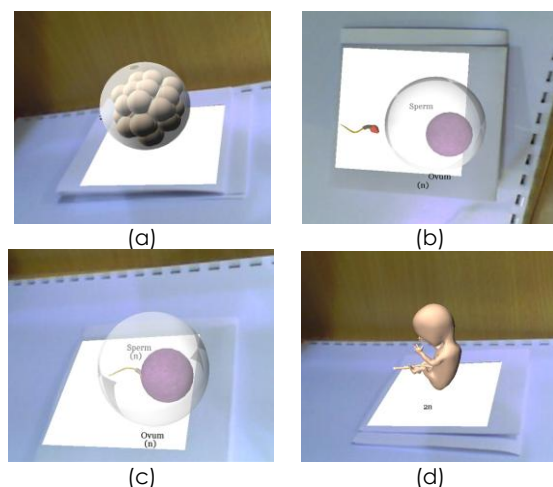

Fig. 5. The ATTech system presents the process of meiosis, from (a) blastocyst, (b) and (c) the fertilisation of ovum by sperm, to (d) formation of embryo and foetus. The overall process is shown by the animation of the 3D object superimposed on top of the book, accompanied with text and audio explanation

Figure 6 shows the different type of cells and few examples of organelles that presence in the cells.
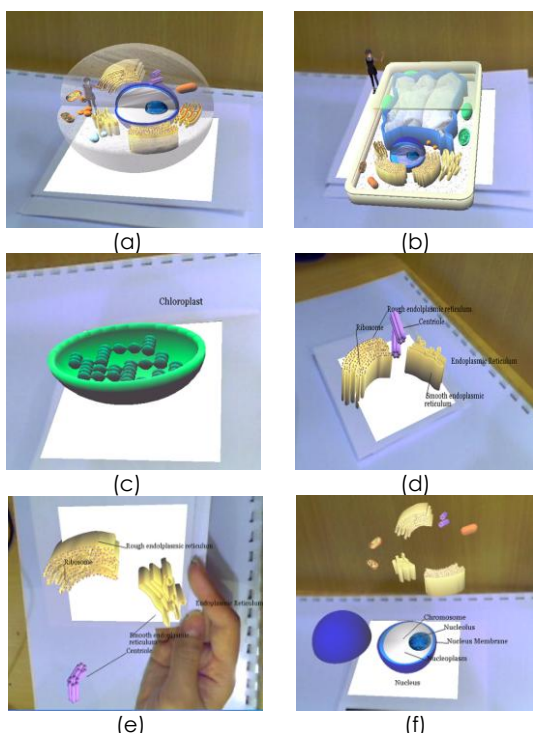
Fig. 6. 3D objects are presented by ATTech system. The 3D (a) animal cell; and (b) plant cell, both with the "virtual teacher" inside the cells, walking around to explain the different organelles could be found in both cells. The 3D (c) chloroplast; (d) ribosome, centriole, and different types of surface of endoplasmic reticulum; (e) students can rotate the book to see the 3D objects from different angles; (f) 3D nucleus and its components found in the cells

These lessons are presented in dedicated stereoscopic and photo-realistic views, thus facilitating learners in noticing, memorizing and understanding Biology concepts. Also, it allows learners individualized interaction while enabling social communication, given thinking is but epistemic in its nature and that its organization has both individual and social dimensions.

The ATTech system is not only just showing 3D objects, animations, text, and audio, but it also provides interactive buttons for the students to interact with the system through mouse clicks. Figure from 7 to 10 show the samples of respiration processes that would prompt the students to interactive with the system by the presence of interactive buttons.
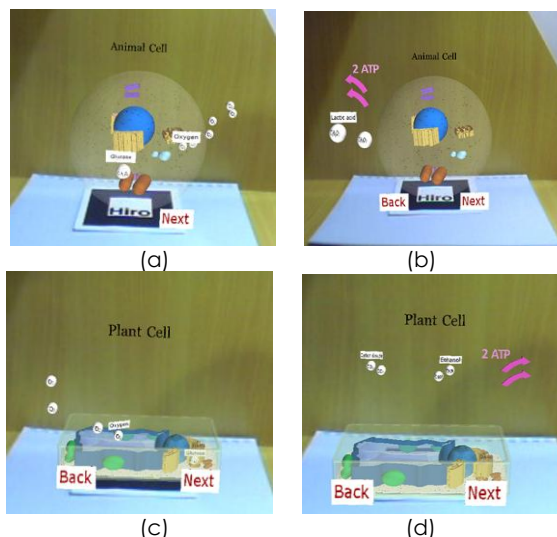

Fig. 7. Processes of cell respiration (aerobic respiration) in animal cell and plant cell. 3D animation of (a) animal cell and (c) plant cell, showing the intake of oxygen molecules in the beginning of the process; where the release of (b) lactic acid molecules and 2 ATP and (d) carbon dioxide and ethanol molecules, and 2 ATP, is also shown at the end of the process in the animal and plant cell respectively. The processes shown in both animal and plant cells are complemented with "Back" and "Next" buttons for students to interact with the system through mouse clicks
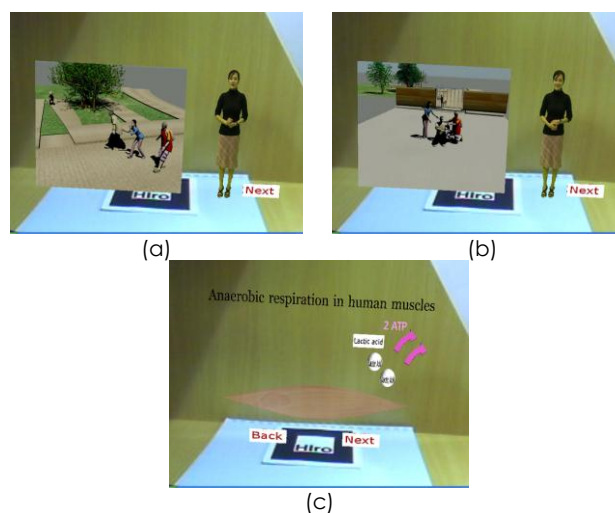

Fig. 8. The ATTech system presents the scenario which would cause the anaerobic respiration of cell in human muscles. (a) and (b) showing the scenario presented in the form of 3D animation, which the lady "virtual teacher" was standing at the side to tell the story. Later if the students click on

the "Next" button, the process of the anaerobic respiration in the muscles is shown in (c), together with the energy release
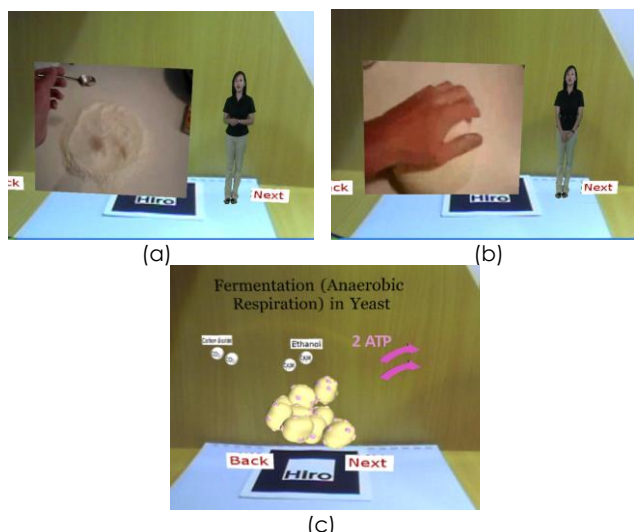

(a)

(b)

(c)

Fig. 9. (a) and (b) is a video showing a phenomenon (yeast fermentation while making bread) which would cause the anaerobic respiration in yeast. The "virtual teacher" is presence at the side of the video to explain what is happening in the video. The interactive buttons also presented in the system, allowing students to interact with the system. By clicking the "Next" button once the video has ended, the process of the anaerobic respiration in yeast is shown in (c), together with the energy release and by product (ethanol)
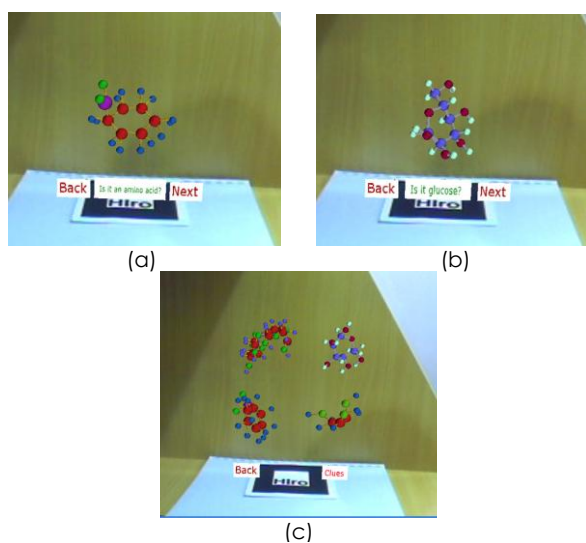

(a)

(b)

(c)

Fig. 10. Exercises are presented using ATTech system. (a) and (b) show the 3D structures of different molecules which complemented with the questions below for students to answer. The 'Clues' button, which shown in (c) also presented to provide hints to students. This makes the interface more students friendly and students are more encouraged to participate in the exercises.
*** Term animation need to add in

ATTech system has many advantages such as flexibility, inherently safe, intuitive and interactive, where the students can learn effectively by 'doing' and enhance sense of presence by interacting with the system in learning complex processes.

V. ADVANTAGES OF AR IN EDUCATION

The advantages of using AR address issues relating to education:

a) Simplicity: Simple controls to adjust sensitivity.

b) Easy to learn, ease of use: No calibration. No special maintenance.

c) Sensitivity: Enable students to detect individual components.

d) Selectivity: Enable to differentiate between various sources of equipment emissions, even when components are within close proximity.

e) Accessibility: Slim and lightweight tool with selectable length probe attachments for easy access to difficult-to-reach locations.

VI. SUMMARY

AR technology provides a better means for students learning in an interactive environment. It allows students interact while enabling social communication. It enhances the effectiveness and attractiveness of learning environment in a real world scenario. AR technology introduces a new type of automated applications and to enhance the effectiveness and attractiveness of learning environment for the students in a real world scenario. This AR study contributes on merging computer vision, image processing and computer graphics to form a new HCI paradigm. AR allows the learners to promote reflection of the metacognitive processes, through "transfer" of learning.

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