



MOBILE LEARNING APPLICATION BASED ON AUGMENTED REALITY FOR SCIENCE SUBJECT: ISAINS

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ABSTRACT

The use of technology in education is no longer foreign. Various forms of technologies have been applied in order to attract and increase students' attention in the learning process. Therefore, the development of an application based on science education which includes Augmented Reality technology and Thinking Map concept are considered desirable. The development of this application is mainly due to the identification of several shortcomings by the lack of students' involvement during the teaching and learning process, less mobile aid learning approach, and lack of existing mobile application for science subject for primary schools. The main objective of this research is to design and develop a new mobile application that can be an additional tool in learning science. This application called iSains was developed based on Rapid Application Development methodology for two topics which are the day and night, and moon phases. This research has contributed to the development of mobile application of science subject for primary school in Malaysia by integrating a new emerging technology in education which is Augmented Reality that allows students to view 3D model of moon phases through their text book. Thinking map concept has also been implemented in the application in order to improve the organization of the learning content. This mobile application is expected to assist primary students in Malaysia to learn about the day and night, and moon phases, effectively.

Keywords: mobile application, augmented reality, learning, science.

INTRODUCTION

The education system in Malaysia is teacher-centered and more geared towards preparation (Bestari, 2013). There is a lack of variety in learning style because students are not actively involved in the process of teaching and learning and this will indirectly affect their thinking level. This has been proved by a study conducted by a consultant Kestrel Education (UK) and 21 Century Schools (USA) on November 2, 2011 where they found that high-level thinking among teachers and students in Malaysia is very low (Kurikulum., 2012).

Learning Approach using mobile applications is still not very popular in school environment in Malaysia. Learning approach is still based on the learning-centered class and geared towards examinations (Bestari, 2013). Although there are now a variety of other learning media such as newspapers, television, and the internet but learning through Android mobile application has not been used effectively as an additional tool in learning.

Furthermore, there is still less science learning applications on the market that covers the syllabus set by the Ministry of Education (MOE) for subject science. Most of the existing applications developed according to abroad syllabus or too general to be used as an additional tool in supporting learning science in school.

The main objective of this research is to design and develop a mobile application for the topic of day and night, and the moon phases. In designing the application, an appropriate thinking map will be selected based on the aforementioned topics. This work also involves the integration of Augmented Reality (AR) that allows students to view a 3D model of the day and night and 3D model in moon phases through the use of a mobile phone and the textbooks for year five's Science subject. Target

groups for the development of this application are year five primary school students. The navigation interface, as well as the instructions found in this application used the Malay language as the medium.

In this research, we make the following contributions:

1. We develop the content of the mobile application based on thinking maps in order to organize the summary of each topic effectively.
2. We develop a mobile application that integrates the use of AR in order to increase students' attention towards specific topics in science.
3. We develop exercises for each topic in order to increase students' understanding.

Section 2 describes the prior work done on mobile and AR. In Section 3, we describe the main components of our application which include e-content based on a thinking map, exercises, and augmented reality modules. We conclude the research in Section 4.

RELATED BACKGROUND

Thinking map

Thinking map was first introduced by David Hyerle through his writings as "Expand Your Thinking" in 1988 (Thinking Maps Inc, 2011). Thinking map is divided into eight types of forms that are a circle map, multiple bubbles map, bubbles map, tree map, brace map, flow map, multi-flow map and bridge map. Each type of map is shown in Figure-1.



Thinking Maps®

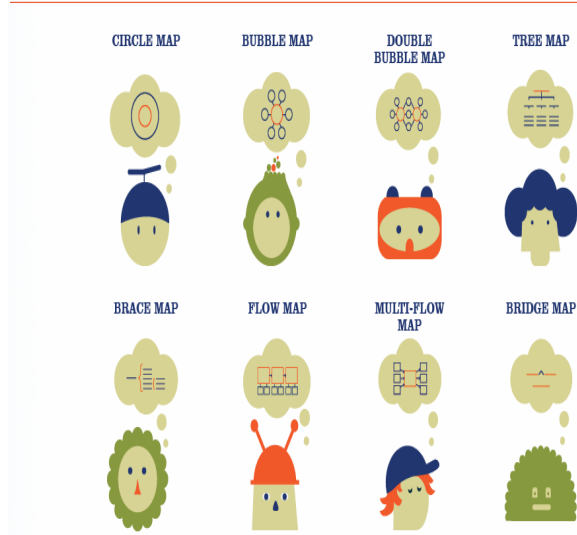


Figure-1. Thinking Map (Agensi Inovasi Malaysia, 2012).

Augmented reality

According to Azuma (1997), Augmented Reality (AR) is a variant for a Virtual Environment or better known as virtual reality. AR is defined as technologies that combine the virtual object on the world of reality as well as allows its users to interact with virtual objects (Azuma, 1997). As AR interface allows users to view the virtual objects on top of the real world using a device, users can experience the real world deeper than the use of other computer interface (Billingham, 2002). AR technology allows users to view virtual objects overlaying on the screen of their smartphones. There are a number of elements or equipment essential in running the application. These elements are: smart phones, installation software for AR on smart phones, cameras and marker for detection. When the smartphone's camera scans and detects the marker that have been specified for the application, virtual

objects that were designed for the marker will be displayed on the smartphone screen. Figure-2 shows elements in using a smart phone for AR applications.

Mobile applications in science

There are a number of mobile applications for science as shown in Table-1 for example. GCSE Core Science and Pocket Planets can be downloaded from Google Play, whereas AR Solar System from App Store. All of the applications are easy to navigate, have interesting interface but no audio. GCSE Core Science contains a lot of information but also a lot of text Figure-3 Pocket planets and AR solar system have medium to low text but quite heavy to be loaded. All the applications use English as the main language. This will make it difficult for students to understand the content that appears on these applications as the Standard curriculum for primary schools (KSSR) for the subject Five-Year Science is now in Malay language. Therefore, our proposed mobile application, iSains, will be based on Malay language.

Virtual information on the screen



Tracking the marker using camera phone

Figure-2. Augmented reality using a smart phone.

Table-1. Comparison of mobile application for science.

	GCSE Core Science	Pocket Planets	AR Solar System
Theme	Science	Solar system	Solar system
Medium	English	English	English
Key feature	A lot of information about science	Good interactivity	Combine AR and brief information
Multimedia element			
Audio	No Audio	No Audio	No Audio
Text	High	Medium	Low
Graphic	Low	High	High
Video	No Video	No Video	No Video

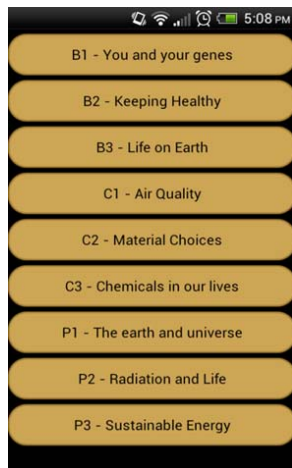


Figure-3. Contents for GCSE Core Science.

However, it presents great challenges to develop a well-designed mobile application for children in primary schools. The key problem with poorly designed application according to Ching *et al.* (2009) is that the application may place extraneous cognitive loads on students. The characteristics of the applications are that they are complex, difficult to control, and less graphic and visualization (Marty *et al.*, 2013). This situation, together with the lack of needed functions, has led to difficulty for accomplishing the goals of the applications (Cole and Stanton, 2003). The problems in the development of interfaces that are effective and satisfying for students to use have motivated this research to use augmented reality technique and thinking map concept to develop a new mobile application for science. This emphasizes the origin of the main research question: Does a mobile application based on augmented reality technique and thinking map concept, effectively assist students in achieving the learning outcomes.

THE DEVELOPMENT OF iSAINS

Method

Rapid Application Development (RAD) was selected as the methodology for the development of mobile applications iSains. Four main phases in RAD are planning, design, development and implementation. The related software in developing the application were: 1) Eclipse Integrated Development Environment (IDE) for Android platform development using Java (The Eclipse Foundation, 2013), 2) Metaio Software Development Kit (SDK)(metaio GmbH, 2014) for augmented reality development, and 3) GIMP for image editing (The GIMP Team, 2013). Since iSains was developed to integrate AR, the framework used in this work was based on the augmented reality framework developed by Metaio. The framework for the application is shown in

Figure-4. There are four layers in this framework: (1) application, (2) high level Application Programming Interface (API), (3) Metaio SDK and (4) operating system (OS)(Abd. Majid, 2013).

The application layer focuses on graphical user interface application and operation logic. This layer allows a direct access to the high level API layer. The API layer is a platform-specific programming interface that supports Java for Android SDK, Objective C for iOS SDK and C++ for Windows. Android SDK based on Java was used in this research because iSains was developed for Android platform. In this API layer, there are several classes and functions that can be used by the programmers to interact with the metaio SDK. Metaio SDK, the third layer, provides components for an augmented reality enabled application. There are three key components in metaio SDK: capturing, tracking and rendering.

The capturing component configures a camera and provides an image from the camera. In the tracking component, the tracking configuration needs to be loaded first in order to specify a marker. The tracking component can then process the captured image from the capturing component in terms of its position, scale and orientation of the marker relative to the camera. When the marker is recognized, the rendering component loads a model or configured on the screen. The fourth layer is OS layer which combines all components of the framework is based on the selected platform.

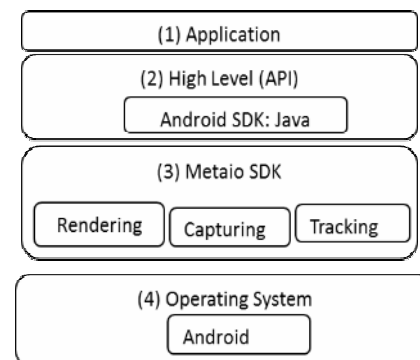


Figure-4. The framework for AR based application.

The capturing component configures a camera and provides an image from the camera. In the tracking component, the tracking configuration needs to be loaded first in order to specify a marker. The tracking component can then process the captured image from the capturing component in terms of its position, scale and orientation of the marker relative to the camera. When the marker is recognized, the rendering component loads a model or specified computer-generated information that has been configured on the screen. The fourth layer is OS layer which combines all components of the framework based on the selected platform.

In the design of the application, two thinking maps were selected out of eight thinking maps. The selected thinking maps are double bubble map and flow map. In order to mix these virtual information and real world, AR can play a significant role in improving teaching and learning. Integration of augmented reality technology allows students to view a 3D model of the day



and night and 3D model of lunar phases on the science text book through a mobile screen.

Feature of iSains

There are two main modules in iSains: 1) learning module (eModul) and AR module (Galaksi Maya) as shown in Figure-5. The main menu of the application consists of two buttons. Button eModule is for accessing the e-content, whereas button Galaksi Maya is for AR based application.



Figure-5. Main menu in iSains.

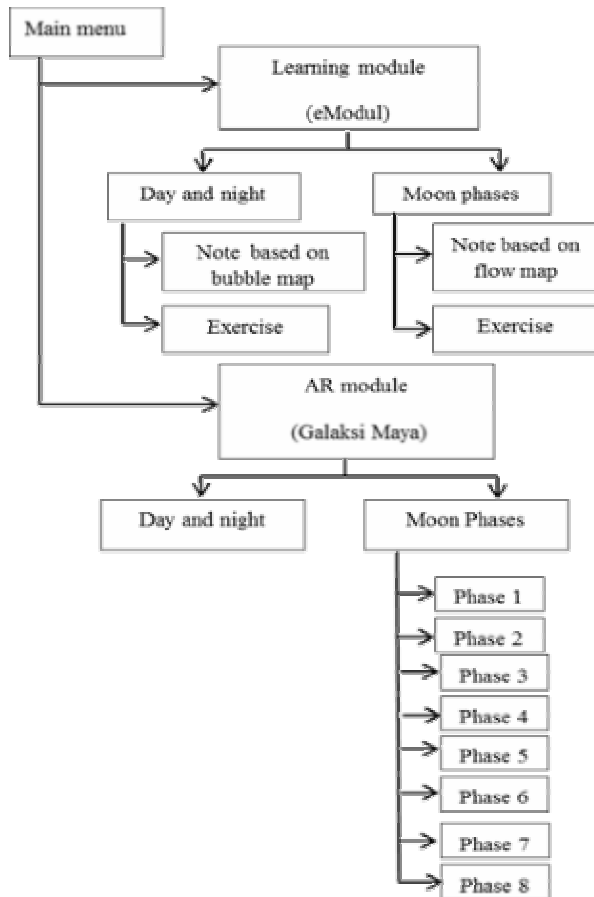


Figure-6. Module design for mobile application: iSains.

The first module, eModul, and the second module, Galaksi Maya, consist of two topics, the day and night, and moon phases as shown in Figure-7.

Note based on thinking concepts and exercise (eModul)

When a student clicks on the topic the day and night (“siang and malam”) in the eModul (Figure-7 (a)), the e-content for this topic will be displayed as shown in Figure-8(a). Thinking map selected for this topic is multiple bubbles map. This map was selected in order to compare the characteristics of the day and night in terms of similarities and differences. When the student click topic moon phases (“Fasa-fasa bulan”), the content which is based on flow map will be displayed as shown in Figure-8(b). This topic was summarized based on the flow thinking map. This thinking map was selected in order to reflect the changes in phases.

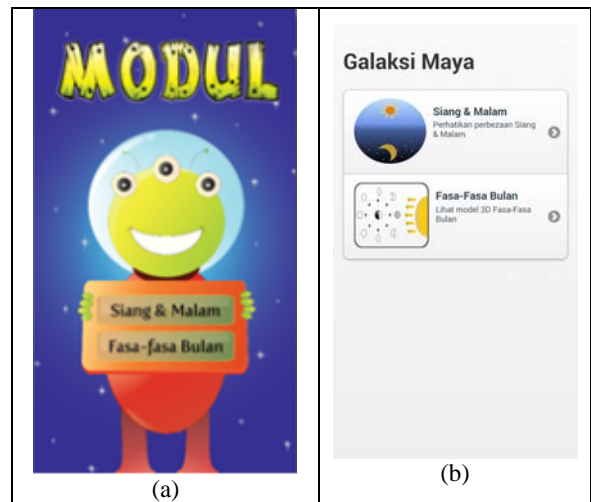


Figure-7. The main menu for: (a) the eModul and (b) AR module.

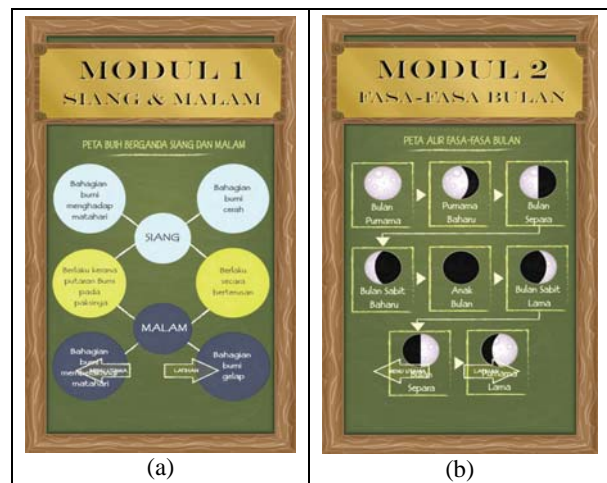


Figure-8. eModul (a) Day and night based on double bubble map and (b) Moon phases based on flow map.



After examining the summary of the topic, the student can proceed in completing the exercise for this topic in order to test their understanding on the topic day and night (

Figure-9) and topic moon phases (**Figure-10**). The exercise was generated based on the content in eModul and the aim of the exercise is to identify the level of understanding of the students. If the students fail to give a correct answer, a message will appear on the screen to encourage student to try again.

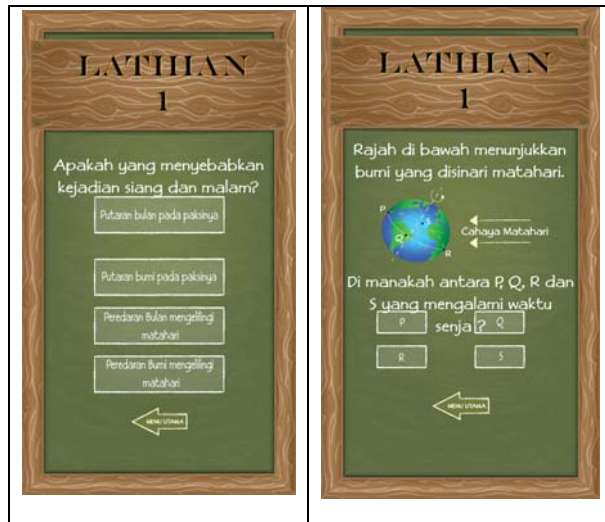


Figure-9. Exercise for topic the day and night.

AR module (Galaksi Maya)

When the students select the day and night topic in the virtual galaxy module as in Figure-7(b), they will see a menu to start AR based application, as can be seen in Figure-11(a). A 3D model that shows the differences between day and night will be displayed on the phone screen as shown in Figure-11(b). This will occur when a student scans a pre-identified marker which is an image of unit 11 using the camera phone. This 3D model describes the situations where as the earth rotates, areas of the earth facing the sun will experience day and areas of the earth facing away from the sun will experience night.

When the students click topic moon phases (“Fasa-fasa bulan”) in virtual galaxy module, they will also see a menu to start AR based application. When they click a button on the interface and scan a marker in the text book for subject Science year 5, they can see a 3D model for each phase in moon phases as shown in Figure-12 for example. In AR module also contains eight buttons: Phase 1, Phase 2, Phase 3, Phase 4, Phase 5, Phase 6, Phase 7 and Phase 8. This allows students to view a 3D model for eight major phases in lunar phases. Each 3D model will be displayed with audio in order to capture students’ attention.



Figure-10. Exercise for topic moon phases.

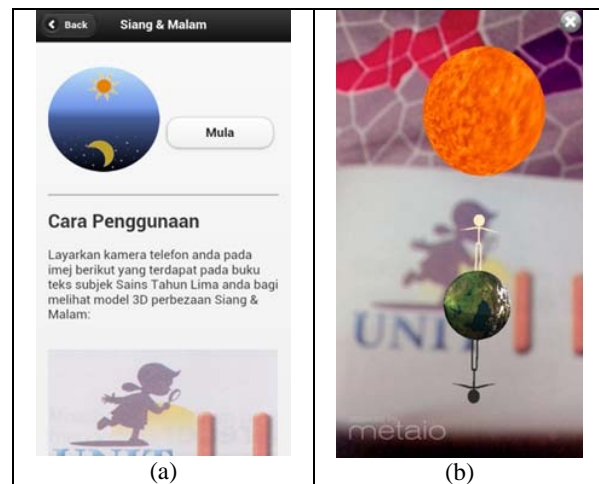


Figure-11. AR based application for the day and night (a) the start button (“Mula”), (b) the 3-D model.

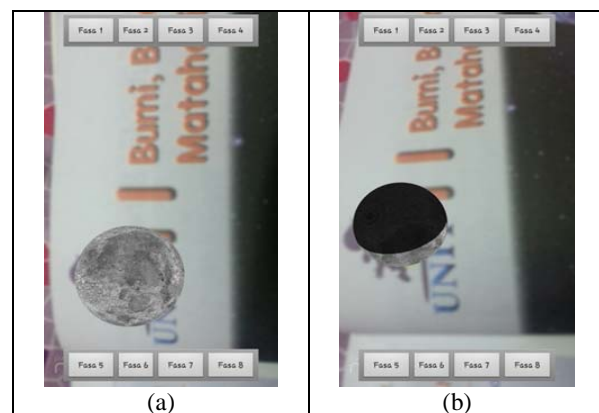


Figure-12. AR based application for the day and night (a) the start button (“mula”), (b) the 3-D model.

Data analysis

In order to observe students’ experiences in using the proposed application, observation reports containing



questions such as “Do the students know how to begin the application”, “What difficulties do they have” and “How long do the students take to do the AR module”, were implemented. Two students from the primary level had participated in the evaluation session. Analysis of the observation reports revealed that students knew how to begin the application because there were only two main items in the menu which are *eModul* and *Galaksi Maya*. One of the difficulties occurred while using the application is that the students could not figure out how to proceed to after observing the content in *eModul*. The students overlooked the navigation options. This navigation issue also occurred in the earlier prototype in the design of mobile learning application to support scientific inquiry (Marty, *et al.*, 2013). Therefore, this navigation options need to be improved for iSains application in order to achieve a successful adoption of the application in the classroom. This is because the key for successful adoption is the development of the interfaces that are effective, efficient and satisfying for students to use (Hussain *et al.*, 2008).

In terms of the time taken to do the AR module, the students took a few minutes to adjust the marker so that the application can successfully track the marker and overlay the 3-D model on the mobile screen. This delay is caused by low lightning for the mobile phone to accurately detect the marker. However, once the 3-model overlaid on the screen, the students were attracted and enjoyed observing the models. The models need to be improved by adding interactivity on them so that the students will be more engaged via the application. Overall, a mobile application based on augmented reality technique and thinking map concept, is moderately effective in assisting students to achieve the learning outcomes.

In order to further increase the students' understanding, animation and audio should be added to the e-content of the day and night based on double bubble map and moon phases based on flow map. This is because during the observation, the students tried to touch on the content to see more explanation.

CONCLUSIONS

A mobile application integrated with augmented reality and thinking maps concept has been developed for increasing students' interest towards science subject. This application called iSains, contains two main module *eModul* for e-content and *Virtual Galaxy* for AR. A variety of multimedia elements have been loaded on both modules, for example, text, graphics, 3D models, audio and interactivity. There are several advantages in using iSains such as the application can be used freely on android mobile phone, and the interface is attractive and user friendly. This application is a viable option for students in primary school to engage them with the learning process as it offers a new technology as the learning platform. More works is needed to include more topics and interactivity in the application.

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