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C-Heart: Augmented Reality of 3D Heart Anatomy

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ABSTRACT

This research paper is to enable the researchers to create a unique Augmented Reality (AR) internal organ in 3D and mobile e-learning application. This mobile e-learning application will include multimedia elements such as audio, video, graphics, and text. In the other words, the AR mobile application has a trailer, realistic sound effect and 3D interactive model. From adults to children, they are active users using mobile or smartphone as a tool for communication, work, recordings, and entertainment. From that perspectives, the advantages of smartphone will be benefits for educational field, specifically in medical field as many obstacles are experienced by the students in remembering the human body organs structure. ADDIE design methodology; a standard waterfall development model is being used in this research and the data collection is done through interviews with the doctors from Banjarbaru City Hospital, Banjarbaru, Indonesia. As the result, the mobile e-learning application of Augmented Reality is developed and can be implemented to medical e-learning system, especially in Indonesia in order to upgrade the education system. Therefore, the application can facilitate the way of learning and teaching in this modern generation, especially in medical field.

Key words : 3D learning, augmented reality; e-learning; interactive learning; mobile learning

1. INTRODUCTION

The teaching technique has always evolved to the present day. While technological advances, there are now many easy teaching methods and much liked by people. Nowadays, many schools are implementing online systems for students and teachers, supported by smartphone in every high school students. Studying human body organs structure is one of the basic and important subjects in biology. The different structures and components of organs allow us to know how it works and what its function. The heart, lungs, and stomach of human have its own function and work. Therefore, biology has something interesting and useful to learn.

Many obstacles are experienced by students in remembering structure names and function. With the development of technology, there are various ways people learn and practice. The choice of students to learn depends on those who can use and access the various technologies and infrastructure available in the school. Today, people's lives are transformed into modern generations, almost everybody now can online and the smartphone users is forecast to grow, with around 223 millions of smartphone users in 2017 [1]. People are using smartphone for communication, business, entertainment and education. It can motivate researchers and technology developers to make education and information dissemination easy and fast. To date, there is the latest technology that can combine digital world and real world to simplify the work and become a fun new experience, which called Augmented Reality (AR) and virtual reality technology.

With the advancement of this technology, a mobile application for internal organs in 3D AR is created to give people more interactive biology education, especially to high school student and medical students. Learning convenience can be provided as it offers online and offline material. Additionally, the mobile application also provides interactive learning and entertainment. Students or user can play and learn while see the heartbeat from the application.

The mobile application named as C-Heart and it has two target users that are primary users, which are the students and secondary users, the teachers. Both users are mainly from education and medical related field. The objective of this research is to create a new learning and practice method in biology field among university students, school students and also the educators. The development of the mobile application is based on 3D AR application using smartphone and the aims are:

- to produce educational content that able to support attractive teaching and learning
- to provide AR experiences that can merge physical practice with 3D graphics and digital technologies

This paper is structured as follows. Section 2 will present the literature review. The following section will describe the research methodology used in this research work. Next, section 4 will present the results, which is the mobile application and then discussion. Conclusion is presented in the last section.

2. LITERATURE REVIEW

This section presents a fundamental overview of e-learning system. This section begins by the research domain, which also categorized into four sub-sections which are usefulness of technology in learning activities, student visualization,

teaching and seamless interaction. Next section will be followed by several reviews of existing similar systems.

2.1. Research Domain

In this research, the review is done from different perspective as listed and described below.

2.1.1. Usefulness of Technology and Electronics in Learning Activities

Previously, when e-book discovered by people, not many preferred to read using e-book compared to conventional book and many of them prefer to read from the original book [2]. As to date, e-book responded with a positive feedback and many readers prefer to use e-book due to the ease and effectiveness to learn compare from the conventional books that are heavy to carry [3]. When teachers give lessons, it is usually using a notebook and a blackboard. Nowadays, there is a technology switch, namely e-learning. According to [4], AR can improve students' learning motivation and create a fun learning environment by practicing using it. Hence, it allows AR to be the latest innovation in education by implementation of AR tools and features in mobile learning application. However, this is in fact the greatest challenge for educators to adopt AR in the field of education and practice due to their association with traditional method lessons, AR maintenance cost, and the changing routines for new technologies.

2.1.2. Student Visualization in Real World to Interact With Virtual World

Practical work is compulsory in biology plant lessons. To enhance the understanding of the lesson, they need 3D models of wood and plastic as to depict the real plant itself. However, because the cost is relatively expensive and not durable, it makes the 3D model is less efficient compared to AR. By using conventional teaching method, the teacher having trouble in explaining the plant full structure as the teacher need to draw the plant on the blackboard and this will cause time consuming and produce unclear images. Additionally, it will be difficult for teachers to describe the actual plant structure by 2D drawing. According to [5], AR will produce a cognitive power and learning experience in modelling lesson. Therefore, AR can enhance students learning activities by creating new and fun learning environment.

2.1.3. Teaching

It is difficult for a teacher to bring students' attention in a class especially in a big number of students. In small classes, the absorption of lessons and student concentration increase for a certain duration [6]. Additionally, stable room conditions also affect the learning and student attention, such as temperature, air, light and sound. However, most classrooms nowadays accommodate more than 20 average students, allowing teachers to communicate in a one-way technique and interact with the students afterwards in class. According to [7], students can gain more understanding and catch their attention by looking at certain interesting event or actions that occurred during particular time. AR and E-learning is a new mechanism in teaching and learning and hence, it can motivate students' interest and curiosity.

2.1.4. Seamless Interaction

Practical sessions are very important in evaluating students' level of understanding after learning session. They sit in a group and give attention to the particular task at a time. However, although they sit aside in a group, they are not performing well because the machine is located in front of them [8] and that creates undirected communication. Therefore, a single object that can be viewed from all directions will be suitable to use as a communication tool as it comes from the eye gaze, gestures and mouth. Therefore, AR can be a unifying group of practice and students can see each other very well as they see the real model hovering in centre of the discussion point. This creates a nature feeling result of seeing the interface from the view screen [9].

2.2. Similar Systems

Before the mobile application is deployed, several applications in Google Play Store app, which have the same function to the e-learning system and interactivity learning applications have been studied.

The system that introduces AR in mobile app is **Augment - 3D Augmented Reality.** Augment lets the user to have promotion and marketing in mobile app. Augment has features to upload your product in form of virtual 3D, access and explore the product and use the poster paper to show the virtual product to real environment. Figure 1 shows the application.

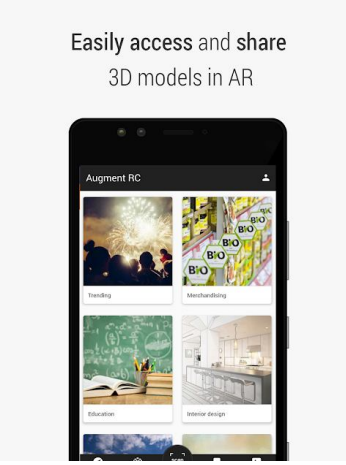

Figure 1: Augment dashboard

Second application is **Internal Organs in 3D (Anatomy)** as shown in Figure 2. The users can access the virtual organ in the mobile phone in form of 3D. The content is good enough and it has all the organ anatomy, structure and function that explained in brief. The apps ease the user to learn anytime and anywhere using mobile phone. Functions that include in the app are rotation, zooming and organ detail explanations. This app do not need any login feature as it just provide sharing of information without any database functions.

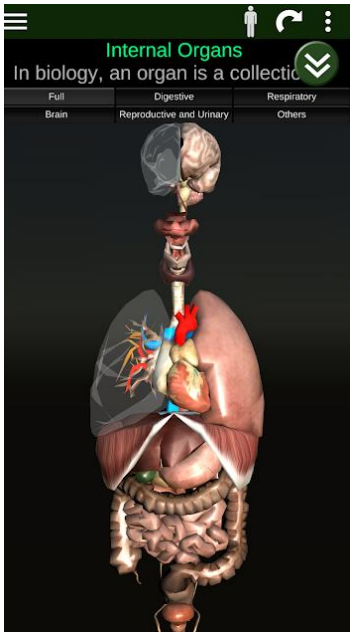

Figure 2: Internal organs in 3D

3. METHODOLOGY

In this research, Project Management Life Cycle is used as the fundamental project life cycle while *Luther-Sutopo methodology* and *multimedia development methodology ADDIE* is compared and the most suitable one is used as to plan, execute and control the development process of a mobile e-learning application which run on Android operating system.

The first acceptable software development methodology is called Project Management Life Cycle. According to PMI [10], "project management is the application of knowledge, skills, tools, and techniques to a broad range of activities in order to meet the requirements of a particular project." There are five phases and if the lifecycle provides a high-level view of the project, the phases are the roadmap to accomplishing it. This Project Management Life Cycle has very details requirement in planning phase, which is good for a project. Moreover, the methodology also gives the developer minimum risk by breaking the project into pieces of task.

3.1. Luther-Sutopo

Multimedia development methodology is initiated by Luther in 1994 and developed by Sutopo which consists of six phases named concept, design, material collecting, assembly, testing and distribution [11]. Figure 3 illustrates the phase of Luther-Sutopo methodology.

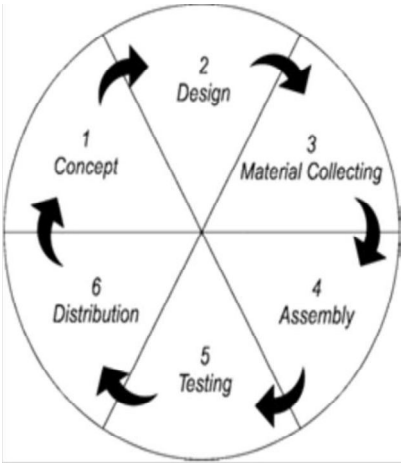

Figure 3: Phases of Luther-Sutopo methodology

First phase is concept phase and it defines the application goal (information, entertainment, practice etc.), user identification (target user), application form (presentation, interactive etc.), general specification (specification size, basic design, goal to be achieve, etc.). This phase goal is to determine which part that could be the guidelines in making the application. Second phase is design phase and it takes unique and interesting content that lies behind it. Strong media elements would add value to a game, so users could feel the platform. Third phase is the collection of materials used in the making of application in the form of text files, pictures, sounds, and other media elements obtained from various sources. Fourth is assembly where those design application interfaces is assemble to display as mobile application user-friendly. Fifth is testing and it is done to check the functions of the application as to ensure it is run well and in accordance with the design that has been structured previously. Finally is the application distribution.

3.2. ADDIE Model

Apart from Luther-Sutopo methodology, another acceptable system development methodology is ADDIE methodology. In ADDIE methodology, less experience project manager able to support the project because of the easy and well-known phases. Figure 4 depicts the ADDIE methodology phases.

The first phase of the ADDIE model is the analysis phase and it includes student needs analysis, context and instructional materials undertaken to determine the characteristics of the intended learner such as previous knowledge, cultural, attitude interest and goals to be achieved. The second phase is the design phase consist of the identification of the learning objectives and the plan is decided along with the delivery method, the type of learning activity, its content and various types of media.

The third stage is a development phase that includes the production of learning content, prototypes and assessment instruments. Next phase is the implementation phase that provides support for learners by providing instructional

materials. This phase can also be called the testing phase, to test the appropriateness and usefulness of the application to the target users. The final phase is an evaluation phase consisting of formative and summative evaluations. In the formative evaluation, program or project is typically assessed during development. This type of evaluation often helps pilot projects and new programs but also can be used to monitor ongoing program progress. In summative evaluation, it is usually used to help decide whether a program should be adopted, continued, or modified for improvement assessed at the end of the operating cycle [12].

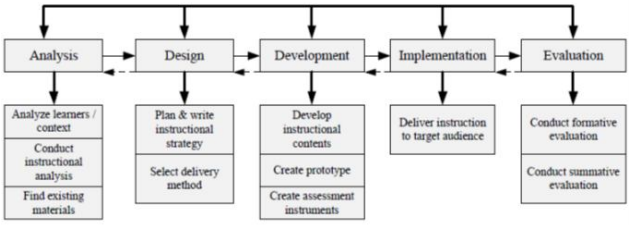

Figure 4: ADDIE model

3.3. Comparison and Justification of Methodologies

This research considered both of the methodologies to be used in this project. Each methodology has their advantages and disadvantages. Hence, this research applied both methodologies by complement each other. As a result, a great methodology has been adopted for this project and it is based on the context of multimedia element and application development. Table 1 below summarise the comparison.

Table 1: Comparison of methodologies

ADDIE	Luther-Sutopo
Total six phases	Total five phases
Step-by-step process to aid in planning and creating training programs	Step-by-step process to complete the project and guideline
Several opportunities to re-evaluate learning goals and outcomes	Provide way to complete the phase before step in to the next phase
Basic model that can be used for any kind of learning and it is very systematic and thorough including all components of other instructional design models	Proper for creating application in a small scope, not too complex and easy to understand

3.4. Research Framework

This research required information and data statistic from the real environment in the case study. Thus, questionnaire investigation has been conducted and it contains closed and easy questions to be answered by the target users of this application. Through the questionnaire, data could be collected for this research. For the case study, medical students in Indonesia, especially South Kalimantan became the target users. Questionnaires can be either paper or electronic form. Due to the distance location factor, this research uses electronic questionnaire. In addition, interviews also are conducted with experts in the field of medicine such as from Banjarbaru General Hospital. The data collected is the expert's experience, suggestions, and also a brief description of the app's content. Observations is made to the target audience before and after the application is created.

Based on the questionnaire conducted, it can be concluded that students from medicine background are commonly have practical classes several weeks in a laboratory with adequate equipment. The students also have course study of heart anatomy and cardiology. The students prefer practical method of study that allows them to get better lesson absorption and experience, but the students do not have computer to do the practical class. To gain more understanding of the lesson, the students also find other learning sources such as from online source. Even though the students have mobile phone, they have no idea what is the current or latest technology.

Therefore, the students are excited for the new experience of mobile e-learning application to support their academic study, especially using AR technologies in their lesson. Rapid technological development should be used as well as possible. In addition, mobile e-learning application is expected to be a new innovation in the learning process, specifically in Indonesia.

4. RESULTS

Augmented Reality Internal Organs in 3D (Anatomy) or named as C-Heart allows user to interact with virtual object. The virtual object is the human internal organ such as heart and its component. Figure 5 and 6 below show screenshot of video and AR of heart in C-Heart e-learning mobile application, respectively.

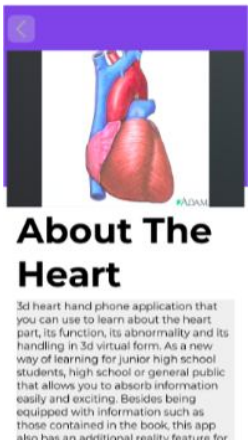

Figure 5: Screenshot of heart video

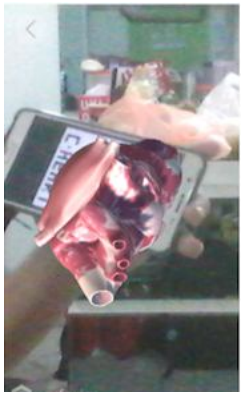

Figure. 6: Screenshot of AR of heart

For first-time user, tracker needs to be printed for the indicator of the virtual object. Users can access organs on their own devices via app. By viewing augmented organs, the users such as students can gain a better understanding of the concept that they are studying. This is a unique and interesting way to engage students and reinforce concepts they have seen during class lecture. With AR, cost for learning material can be saved. Students can access organ models from any devices at any time. Whether they are at home or at classroom, students can study and interact with the study materials. Due to the standalone project, the organ system only limited to blood circulation system. To be exact, this mobile e-learning application focus on heart as the main human internal organ and it is developed in Android operating system. There are 5 main functions that made available to the users:

- Allow end users to download and print tracker
- Allow end users to view virtual organ from smartphone device
- Allow end users to view information about the organ with text, video or animation
- Allow end users to access the heart image and 3D model
- Allow end users to view animation of heartbeat and its function

5. DISCUSSIONS

The content must be prepared properly with reference from the biology book and other encyclopedia book. Based on the pictures and other information that has been obtained, only then it can be proceed with the 3D organs development. Game engine called Unity has been used in creating the AR 3D model. Due to the nature of the mobile e-learning application and the biology theme content, simple and clean user interface is needed. One of the challenges faced in this research is the design and development phase that take much time to complete it.

At the first stage of execution of this research, namely the discussion of problem formulation and goal setting, it is very important to see the problems that occurred in a real scenario. Hence, in this research, data collection is still needs in order to get the exact problem that occurred among medicine students. The data is used to support the research and project works.

To get the optimal results, researchers must look at the latest situations and conditions of science and technology. One of them is the number of mobile applications that are very recent and innovative. It is useful to improve the quality of the existing mobile application. Some existing products do not have innovative features and new product with new features need to be developed and distributed. C-Heart is developed based on the existing mobile e-learning application available in the market nowadays and new feature such as AR is implemented in the app as to enhance the usage in e-learning environment.

C-Heart is specifically developed for medicine students. Thus, research demand for this kind of solution is necessary conducted. The data analysis is done through questionnaire, interview and observation in Medical University of Lambung Mangkurat. Due to the distance, time and cost factors, the survey and interview with medicine students and the doctors has been done through online. The feedback brings in positive result and hence, the research is proceed till the final product, C-Heart is complete and able to be used by the end users.

6. CONCLUSION

This paper has included literature review of e-learning technologies and comparison of existing similar system to the proposed mobile e-learning application. In this research, the system development methodology of ADDIE is used for this project and results of the mobile e-learning application, named as C-Heart also has been briefly discussed above. C-Heart is a mobile e-learning application that created specifically for medical field students as to enhance their knowledge and understanding in human anatomy biology lesson. The application is using AR technologies and based from the research done, it is going to be a new learning environment, especially for students and educators in medical field.

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