The development of virtual electrolysis experiment by using augmented reality for chemistry secondary education during Covid-19 pandemic

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ABSTRACT – This project is about the development of a virtual electrolysis experiment by using augmented reality for chemistry secondary education during the Covid-19 pandemic. The AR mobile app adopts virtual learning using 3D models for secondary education to learn electrolysis. The 3D experiment procedures are developed which enable the students to have more understanding of electrolysis experiments. The objectives of this project are to study AR application and requirements in implementing the electrolysis experiment, develop an augmented reality application in learning the electrolysis experiment procedure, and evaluate the effectiveness of augmented reality in learning electrolysis experiments compared to studying in textbook. Students after using the AR app saw a significant increase in understanding compared to the use of textbooks. Thus, this project benefits the students to learn electrolysis experiments.

1. INTRODUCTION

An experiment is a procedure designed to test whether the hypothesis is true or not. The experiment mostly conducted in the school laboratory or private laboratory. Many different types of experiments will be carried out in order to understand a part of chemistry knowledge such as combustion, preparation of ethanol by fermentation, acid-base titration and the others. In order to carry out an experiment, the people need to remember the rules of laboratory to avoid the accident that easily caused in laboratory. For example, the common accidents in laboratory are eye injuries, chemical irritation and burns from heat [1].

Nowadays, the augmented reality (AR) is one of the biggest technology trends right now. AR let us see the real-life environment in front of us and the use of augmented reality in education is being popularity in schools worldwide. Augmented reality can improve the learning outcomes through interactivity compared to the traditional teaching methods because AR can be extraordinary and more interactive. AR can help teachers to show virtual examples of concepts for providing textbook material support. For example, the traditional visualization methods have a limited capability for enhancing student's understanding of molecular structures. The teacher can use the AR model to simplify 3D visualization to help the students more understanding without using chemical [2]. As a result, EON-XR provides a hands on virtual lab for chemistry students that applied in the safe space for experiments which are AR and VR [3]. The students can just experience the experiments by using their smart phones or computers. In this project, the application will be developed as a marker-less AR application for electrolysis experiment learning. Marker-less AR presents many more advantages over marker-based AR because the virtual object does not need to be anchored to any image or shape in the real world to be visualized [2].

1. Objectives

This project embarks on the following objectives:

- To study AR application and requirement in implementing the electrolysis experiment.
- To develop an augmented reality application in learning the electrolysis experiment procedure.
- To evaluate the effectiveness of augmented reality in learning electrolysis experiment compared to studying on textbook.

2. Problem statement

For the science students, there are many types of experiment that they need to conduct in the school laboratory, but some of the school face the problems about the lack of the material or apparatus needed. Thus, the science students from these schools do not have the chance to conduct some experiments. Although they have the procedure of the experiment, but they will be harder to understand the outcome of that experiments. The experiment in the laboratory is important for them to understand and improve their learning on the concept of certain chapter.

The second problem is the factor of covid-19 pandemic. In 18 March 2020, Malaysia had implemented Movement Control Order (MCO). During this MCO, the students are not allowed to study in school. They are forced to study on online meeting with their teachers. In case, the science students need to conduct an experiment to understand a certain concept of science, especially for chemistry. Therefore, the use of augmented reality on conducting an experiment will give those benefits because they can learn how to carry out an experiment and conclude the reaction of the chemical by using augmented reality at home. For example, AR Lab mobile app is a teaching tool and replacement of traditional class in laboratory.

2. PROJECT METHODOLOGY

The methodology used in this project is Multimedia Development Lifecycle (MDL), which consists of five stages as shown in Table 1. These five stages include

define, plan, implement, construct and evaluate.

Table 1: MDL Methodology

Phase	Activity
Define	In this stage, the domain of the project is stated to solve the particular problem faced by the target user. After the idea of the project was decided, the following step is to search the research of the topic that related to the project. The importance of phase is to determine the goals of the project.
Plan	This stage is important to analysis the background of the project to determine the scope and the project significant of the project. The objectives and the problem statement also determined. The project methodology is drafted to develop the project.
Implementation	In implementation stages, the software that will be used to develop the project is installed in the laptop. Then, the ideas of the features and component in the project are also determined before starting to develop the project.
Construction	The 3D model of the project will be created by using Blender in these stages. After that, this model will be added to the unity to develop a complete AR application. The AR application will be tested to make sure there are no any technical problems. When the application is completed, the demonstration and presentation will be taken.
Evaluate	The project will be evaluated by the target user to determine the effectiveness in this stage. The feedback from the target user will be used to improve the application. The report will be completed in this stage.

3. RESULTS AND DISCUSSION

In this project, the AR technology will be applied for Android smartphone users. Unity is a game engine and integrated development environment used by many developers to build games, utilities, business apps and the other tools [4]. Thus, Unity is the software that will be used to create the scene and interface of this AR application. It is a very valuable tool for the students and aspiring developers because it is being free of charge [5].

Other than that, Blender will be used to do 3D modelling for the apparatus and the materials. Blender also used to create the animation of 3D models. There are two formats that Blender can export the animation to Unity likes native Blender files and FBX [6]. Adobe Photoshop is used to design the 2D graphics such as text design, buttons, background images and logo design. This production of graphics will be combined to create an AR application. For the output, the API level of Android smartphones is at least Android 4.4 and above.

After developing AR app, the user acceptance test was carried out with 3 different experts and 30 end users to verify effectiveness of augmented reality in learning electrolysis experiment compared to studying on textbook. The user acceptance testing for experts and end users will help to evaluate the application in content, learnability, accessibility and interface design. For end user, pre-testing (textbook) and post-testing (AR app) were carried out to test the effectiveness between textbook and AR app. The data from the test show that the student get higher marks after using AR app compared to textbook.

Figure 1 shows the system architecture for AR application. The system architecture is a conceptual representation of the components and sub-components that show the overall behaviour of a system. As the "ARCHEM" application is the marker-less based augmented reality application, so the users view the model on the screen of their phones. User can use their phone's camera to detect the AR apparatus and procedures.

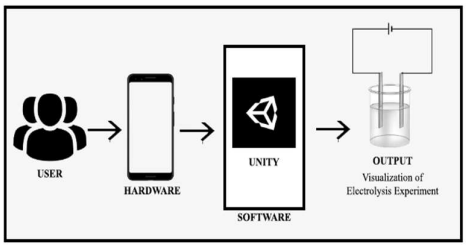

Figure 1 System Architecture

Figure 2 shows the flowchart of AR app. First and foremost, the user will enter the first interface of "ARCHEM". The user will able to click the start to next interface. The second interface is the main menu of this application with three buttons which are lab rules, experiment and the instruction button ("How to use"). If the user clicks "lab rules," they will go to the rules interface. In this interface, they can read the rules with the image that able to let them understand and remember the rules of the laboratory. If the user wants to click experiment, there will have three different experiments buttons for the user to choose. After choosing one of the experiments, they will go to the interface with three buttons which are AR apparatus, procedure and report. If they choose "How to Use," there shows a lot of instructions on how to use this application.

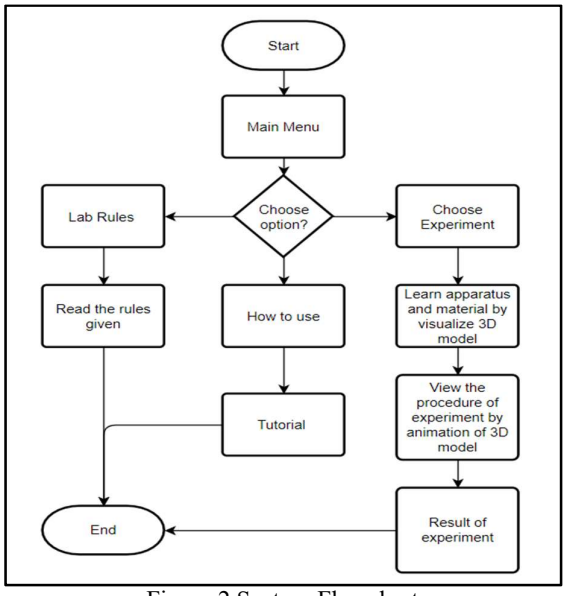

Figure 2 System Flowchart

Figure 3 show the example of the interface design for this AR application after combining all the graphics production in Unity. In this interface, the user will able to view the step of experiment and the reaction happened in each experiment.

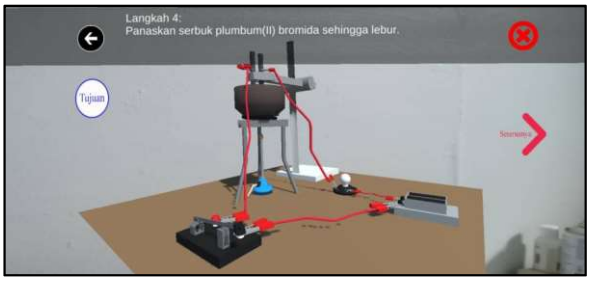

Figure 3 AR experiment procedure

4. CONCLUSION

As a conclusion, the outcome of the project is ARCHEM application which developed by AR with the content of electrolysis experiment. It is the effective learning tool to let the student has more understanding to learn the electrolysis. However, there are some of the improvements required to make ARCHEM become better to use. This project is successfully developed and achieves all the objectives.

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