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Design of Augmented Reality for Engineering Equipment in Education

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ABSTRACT

Education is constantly changing with technology, thus new methods and techniques aligned with technology for teaching and learning need updates especially in engineering education. STEM students need to solve some problems by designing and building using various technologies, thus Augmented Reality is one of the solutions. Traditional learning, less of embedded technology techniques to cater blended and online learning. This research presents a designed of an Augmented Reality (AR) on engineering equipment for education called (AREEE) with android smartphone. 3D images of engineering equipment and tools are designed into an AR platform using Google ARCore, Vuforia and Blender Animation tools. Unity 3D is used to develop the AR mobile application. Google Cloud Storage and Google Cloud Anchors are used to enable multiplayer and multi-devices experiences. This research has created an interesting and masking of the natural and computer-mediated reality for an engineering learning environment with easy access for students and educators to the learning materials as data application. AREEE applications with smartphone is used to scan the tracker and displays some AR 3D model on engineering equipment. Students can interact with the 3D model to create a more engaging learning process. Data analysis of interactivity and benefits of AREEE is presented that shows a positive impact of 80 % on the new AR system. The research is significance to provide better engineering education that engages ongoing perception of a real-world environment that could improve the quality and process of engineering education. It also supports learning society towards digital learning and mixed reality concept in engineering for long distance and interactive education that creates a borderless learning experience especially for STEM education techniques.

Key words: Google ARCore, Google Cloud Anchors, Google Cloud Platform, Vuforia, Unity, augmented reality, virtual reality, engineering, equipment

1. INTRODUCTION

Learning is a continuous and on-going process that never stops but the process of learning is constantly changing from early times to these days. As our technology improves, new methods of teaching and education is continuously developed [1]. Books are gradually being replaced by electronic devices such as computers and smartphone. Mobile Augmented Reality (MAR) has becoming a major interactive technology for cross-domain and destination applications. MAR apps used has increased around the world in excess of 2.2 billion by 2019[2]. Generations of students keep changing and the style of learning is always up to date with the technology in time. Although the way is different, the core of learning is always the same, the acquisition of knowledge or skills through study, experience or being taught. Augmented reality is a new technology which is gradually gaining popularity among technology enthusiasts. Although it has experienced many improvements, the technology may still be considered in its infancy [3]. Augmented reality is the technology of combining real-world images, videos with computer-generated information and imagery. The use of augmented reality is isolated and rare, and the technology never gets enough interest until after recent years. AR is attempts to bring an improvement in the educational and learning system where traditional learning and teaching in classrooms are moving out and utilization of technology are more inclusive and inductive [4]. Augmented reality is a technology that has a broad application, used in literature, commerce, military, games and many more. In education, augmented reality has been used to support the standard curriculum. It is capable of shifting the timing and location of education and training [5]. Augmented reality also enhances the development of university's students in the laboratory [6]. Text, images, video or audio can be superimposed onto a student's real environment. This is done by using markers or triggers that can be detected by the AR device. The marker can be printed or painted onto the objects or a picture for the augmented reality system to recognize the object. This creates an interactive learning process where the students can participate directly with the augmented environment, creating a more engaging and effective learning process. A digital layer of information is added to the environment whenever it is desired that virtually work anywhere. Mobile augmented reality may revolutionize the way information is presented to people today [7].

This research has designed and developed AREEE that interacts between the smartphone as an augmented reality device with images of engineering lab's equipment. It contains markers that are recognizable by the AR device to overlay 3D images of lab equipment onto the real world. The smartphone's camera is used to scan for the markers and when the marker is detected, 3D image of engineering equipment overlaid onto the environment. Vuforia platform based on Google is used for creation of the augmented application to track the marker of engineering tools on the pictures. Unity 3D software with Blender Animation Tools is used to design the 3D model equipment. Google Cloud Storage is to store the application data for the augmented reality application which integrated into the augmented reality application. Data and information from the application is available to access anywhere with internet access. Analysis on AREEE presents 80% of its strength and benefits compare to traditional learning which supports Education 5.0 model for today STEM education.

2. LITERATURE REVIEW

Augmented reality is a promising field and has a very high potential to be more successful in the future. There are large numbers of studies regarding augmented reality such as mobile phone-based augmented reality and augmented reality in education.

2.1 Augmented Reality System

In augmented reality applications, there are various methods used to make the AR character shows awareness of the observer like a portable device is used to capture an image stream of the real world while generating an augmented reality image stream which adds a virtual character. The image is displayed on the portable device. The method used is by generating a virtual representation with the corresponding movement and updating the virtual environment so that the virtual objects interact in the virtual environment, thus creating the illusion that the object directly interacts with the virtual objects.

2.2 Mobile Augmented Reality

Mobile phones are becoming more and more powerful gadgets which acts as sensors, embedded camera and high processing powers, new applications that supports user recent mobile experiences [8, 9]. A mobile augmented reality (MAR) enabled device supports information gathering to determine the proximity and details about the environment. It is a good navigational for locations, object recognition, visual analysis that present a complex user interface with a high graphics capability. These traits result in the ability to blend the real and virtual world together to create an augmented environment for various uses such as in entertainment, navigation and education [10]. Mobile phones are a dependable and promising platform for augmented reality to be more popular and widely used by millions of people. The best augmented reality techniques are to designed on mobile devices. AR-based learning on the Android system has a high potential to be applied in education for example in the learning of chemistry [11].

2.3 Augmented Reality in Education

Looking at the rapid development and advancement of augmented reality technology, researchers predicted that augmented reality has a very high potential and advantages to be applied in a teaching and learning environments [12]. 3D education acts to bring forward with the use of AR technology together with the educational content will create an attractive and effective learning process for the students [13]. Various application and fields of AR have already been explored such as AR in medical applications, AR in general anesthesia, AR for medical training simulations and the use of AR in engineering to help students understand mechanical engineering concepts. in the past, and many of which are connected or related to the education field. Engineering students need engineering graphics courses to further understand the projection of three-dimensional objects. A research proves that students show higher engagement with an AR model during the learning process than using screen-based orthogonal and pictorial images. The tangible and AR model proves to be more effective for engineering graphic courses [14]. Other experiment showed the teaching of mechanical engineering concepts that uses Web3D and AR scenarios visualization of 3D objects. It is believed that the experiment may yield a rewarding learning experience [15].

2.4 Unity 3D

Unity 3D is a software that is popular among the developers to create a 3D design or world. It is widely used to develop games and is considered easy to learn and use. Using the Unity 3D will simplify a game development process. In an AR application, Unity 3D will enhance the AR content and improves the user interface [16]. Unity is a fully integrated development engine for developing games and other interactive 3D content [17]. It can be used together with Vuforia and Blender Animation Tools to develop the AR application. In Blender Animation Tools, there are a variety of ways to create a model like mesh editing and sculpting or even the combination of both methods [18]. The model can then be imported to Unity 3D.

2.5 Google Cloud Storage

Cloud computing is another increasingly popular technology that provides easy access to computing and storage infrastructure using web services. Its advantages are large scalability, high reliability, high performance and configurability. All these are provided with a lower cost than dedicated infrastructures. In cloud computing, users can perform computing tasks where data and information can be accessed over computer networks such as the internet. Google Cloud Storage uses a form of cloud computing called public cloud or external cloud. This type of cloud computing provides services with a pay-as-you-go policy. Customers use these services over the internet with Google as the provider [19].

3. METHODOLOGY

This research project has created an interactive and interesting learning experience for the students. A smartphone is used as the AR device. The smartphone's camera is used as the scanner for the AR marker. When the camera detects the marker, digital images is overlaid onto the environment targeted by the smartphone’s camera. The 3D images are created by using Unity 3D and Blender animation tools and is used as the platform to display the 3D model of the lab equipment. The model must first be created and designed by using Blender animation tools. The models were then imported into Unity 3D. On the smartphone’s screen, the 3D model can be interacted, and users can rotate the model to look at it from a different angle and tap to display the specifications of the equipment and other information about the equipment.

3.1 Flow Chart

Figure 1 shows the flowchart for the developed system that has been designed for AREEE. Three (3) main menu modes have been derived which Group Mode, AR/VR Mode and Standard Mode. Group Mode functions for many users hosting that they create a room that can be joined by other devices for discussion while display the AR engineering equipment shown on the mobile.

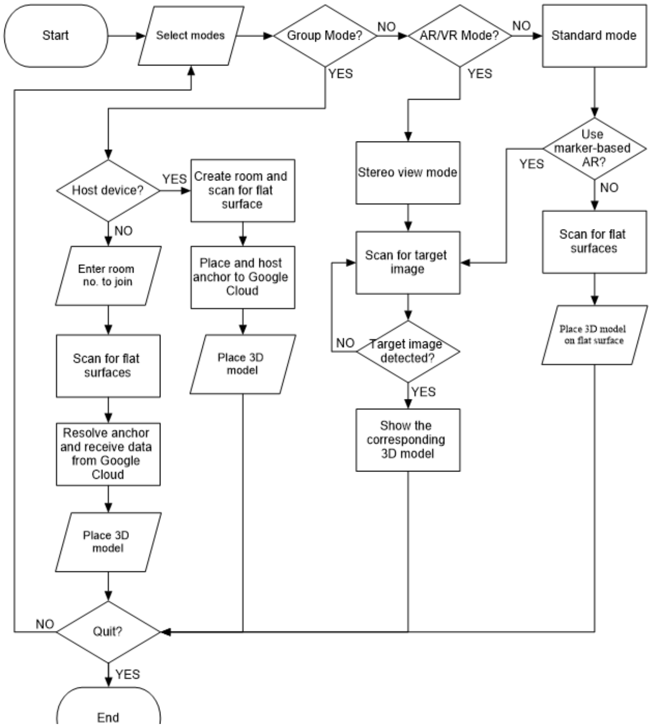
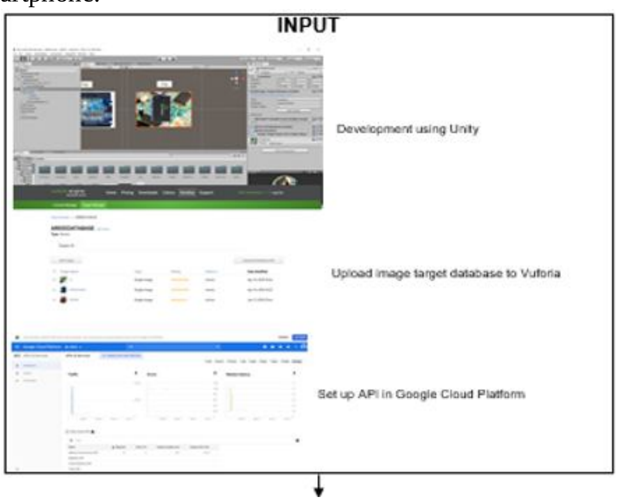


Figure 1: The design application's flowchart

Secondly is the design of VR Mode which viewed to stereo view and the user interface is changed to gazing interaction instead of the normal touchscreen interaction. Third mode is the Standard Mode where users can choose to use image targets or marker less option. Users are to choose image targets, scan the image target to display the corresponding 3D model. A marker less option is also designed where plane detection to detect a flat surface on which the 3D AR model is displayed.

3.2 Architecture Diagram

Figure 2 shows the architecture design of AREEE using 3D Unity that runs on the smartphone. The smartphone's camera is used as a scanner to detect the AR marker. Vuforia is used as the tracker software and after marker is detected the 3D model, a corresponding marker is overlaid onto the smartphone's camera. The model can be interacted with through the smartphone.



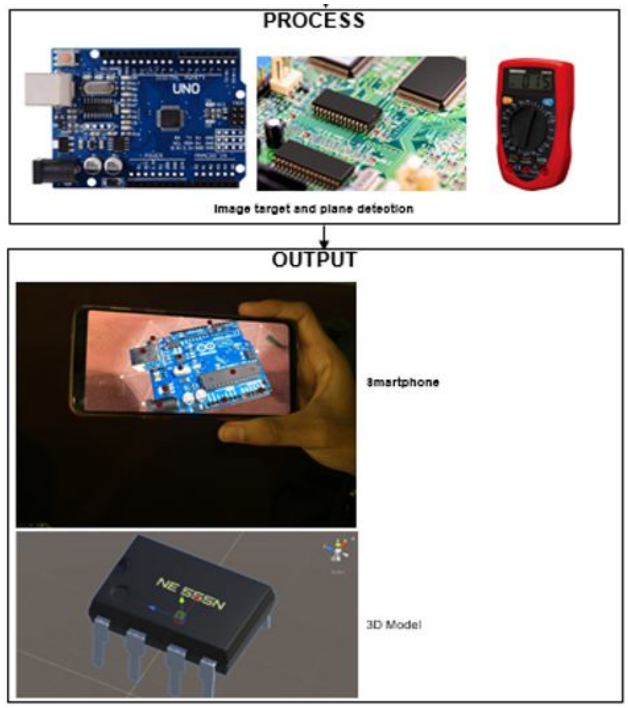


Figure 2: Architecture diagram

3.3 Prototype Design

Figure 3 shows the proved prototype of AREEE on unloadable to the smartphone platform. Image target is tracked by the phone's camera and a trigger acted to display the 3D model onto the smartphone's screen.

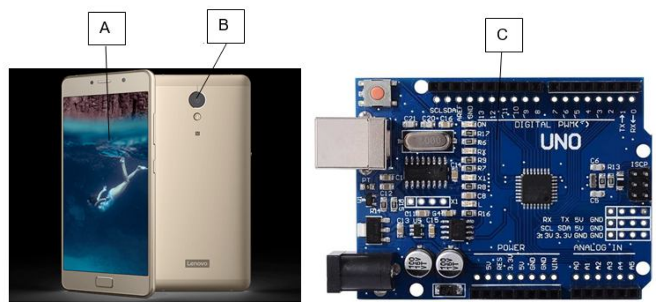


Figure 3 Prototype design

Features

A = Screen display. To display and interact with the augmented environment

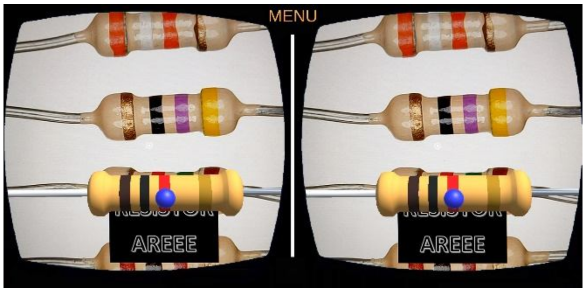
B = Camera. To scan for target images and flat surfaces

C = Image target. A trigger image for the augmented software

3.4 Interface Design

Figure 4 shows the design of the interface for AREEE that presents the camera used to scan the target image or flat surfaces. The target image is successfully detected and it automatically corresponding to display a 3D model of the engineering equipment overlaid onto the phone's screen. Various target images are uploaded to the database for different engineering equipment as presented samples of engineering equipment. Users can interact with the 3D model through the smartphone and find its details information of the image target in learning the equipment specifications.

Standard Mode



AR/VR Mode

Figure 4 :AREEE Interface design

3.5 Hardware

The smartphone that equipped with a camera and capable of running the AR application is used. Android version of 7.0 and above is required to support Google ARCore. The smartphone is the platform which runs the AR application. Android Studio is used to program the software for the Android phone. Unity 3D is with 3D model is derived using the Android Studio and Blender Animation Tools on the phone. The smartphone's camera act as a scanner to track the target image. Vuforia is used as the tracking software. When the camera detects the target image, virtual information is overlaid onto the camera's environment. The target image functions as a gateway between the real world and the virtual world.

3.6 Software

Software like Unity 3D, Blender Animation Tools, Vuforia, Google ARCore and Google Cloud Platform are used to implement the AR application. Unity 3D is used to design the AR application. It is used together with Blender Animation Tools to create the 3D model of the engineering equipment. It is widely used for AR related projects. It operates in JavaScript and C#. Blender Animation Tools is used to create the 3D model of the engineering equipment. The model is exported to Unity 3D. This is because, in Unity 3D, only some default models are present. A new model must be created manually using the Blender Animation Tools. Google ARCore is used for markerless AR mode. It uses plane detection and enables the users to place 3D models on any flat surfaces. Google Cloud Anchors is used for multiplayer experiences and sharing the 3D model using the Google Cloud Platform to host and resolve the data. Vuforia is used for target image-based AR mode. It is a computer tracking software that used by the smartphone's camera to track the target image. Google Cloud Storage is used together with Google Cloud Anchors for multiplayer experiences between multiple devices. It is used to host the anchor data which can then be resolved to synchronize data between multiple devices.

4. RESULTS & DISCUSSION

4.1 Prototype of AREEE

AREEE prototype applications on mobile phone is developed which shows an AR application for engineering equipment for engineering learning tool. The smartphone's camera is used for plane detection and tracking the AR target image. Three (3) design menus were developed in AREEE platform as discussed.

a. Group mode

A group mode presents multiple devices which can interact together with the 3D models. This mode uses Google ARCore and Google Cloud Anchors with Google Cloud Platform. The first device will scan for flat surfaces and places the anchor at the position. The anchor is to be hosted to Google Cloud that other devices can enter the same room and resolve the anchor. The anchor is downloaded from Google Cloud and any information or 3D models at the position can then be viewed through all the connected devices together. This is useful for group discussion or lecture session particularly for engineering equipment, where discussion about that particular equipment can be done without presented physically the equipment. Figure 5 shows two devices currently in the same room viewing the same 3D model that are hosted at the location.

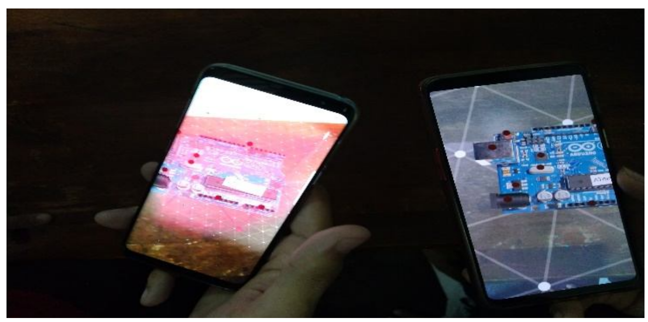


Figure 5: Group Mode

b. AR/VR Mode

In the AR/VR mode, the view of the AREEE applications is changed to stereo view. This mode combines AR with virtual reality, providing a hands-free experience. Users with VR box available can put their smartphone into the VR box and interact with the 3D model just by gazing or looking at the 3D model, without the need to use their hands. This can be useful in situations where the users may need to take notes, draw sketches, etc. Figure 6 shows the stereo view of the user interface of the AR/VR Mode with buttons for gazing interaction.

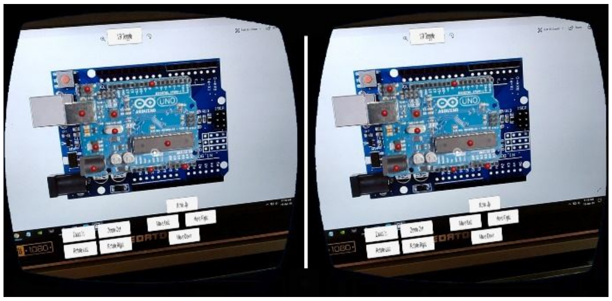


Figure 6: AR/VR Mode

c. Standard mode

In standard mode, the users can choose between marker-based AR or markerless AR. For marker based, image targets are used as the trigger to display the 3D model. When the image target is detected, the corresponding 3D model for the image will be displayed. For markerless AR, Google ARCore is used for plane detection and the 3D model can be placed on flat surfaces such as the table or the floor. The 3D model can then be interacted with using touch gesture such as rotate, scale and move. Figure 7 shows the Standard Mode using a target image while Figure 8 shows the Standard Mode using markerless AR.

Figure 7: Standard Mode using target image

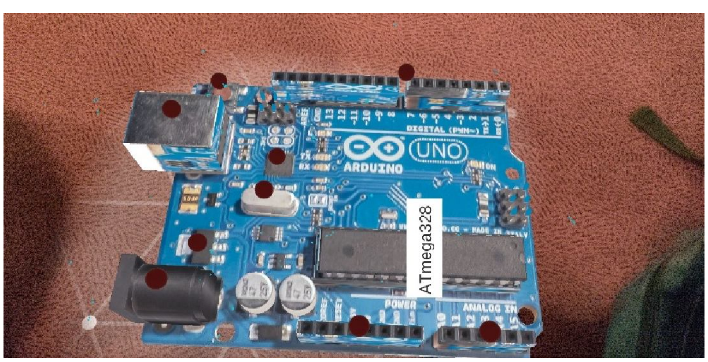


Figure 8: Standard Mode using markerless AR

4.2 Data Analysis

A set of 30 participants were selected to test the AREEE application. Their feedback is taken using a set of question using Google Forms. Five categories of questions are given to each participant to collect their feedbacks on various topics. The categories are the users experience on AR, users experience test on the AREEE system, users experience test for educational experience, other suggestions on AREEE and AR apps, and improvement for future modification.

a. Users Experience on Augmented Reality

Users' experiences using AREEE to analyse level of knowledge of students on AR in general. Three questions are surveyed based on students acknowledge with AR, experiences with AR and does AR benefits them in teaching and learning as future tool. Figure 9 to 11 show the students response for 30 students with surveyed scale.

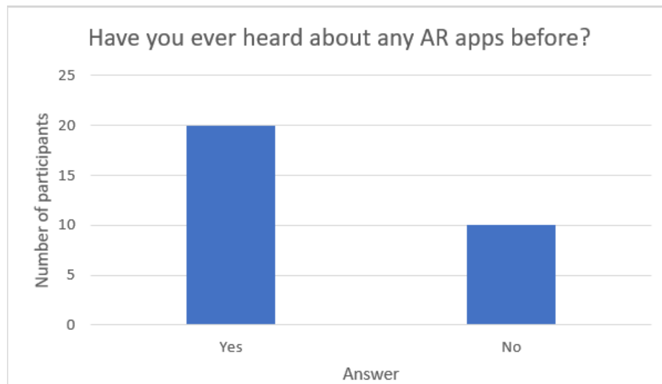


Figure 9: Knowledge on AR

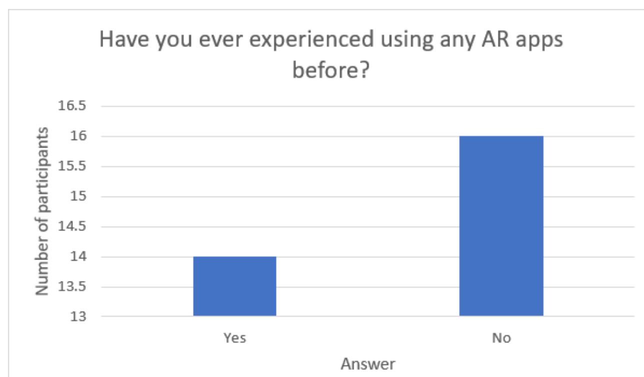


Figure 10: Experiences on AR

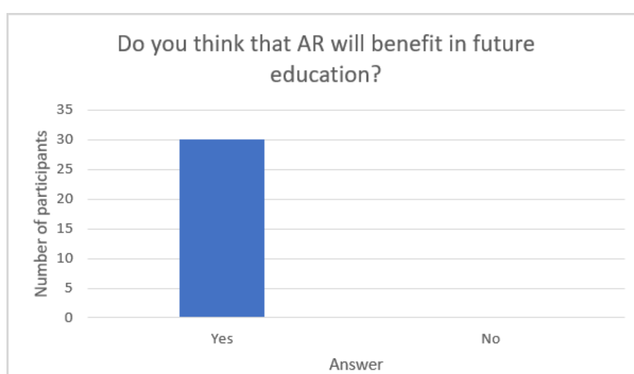


Figure 11: Benefits of AR in future trend

b. Users Experience Test on AREEE System

The prototype of AREEE applications has been promoted and install on phones. Based on the application, users experience test on AREEE system has been analyzed that aim feedback on using the AREEE application. Students responded on questions surveyed such as time using AREEE, ease of using AREEE, interactivity, interesting and how they rate the AREEE application. Figure 12 on spending time on using AREEE shows the minimum and maximum time spend are 5 minutes and 1 hour respectively. Figure 13 shows the responded for ease of use presented on scale from 1 to 5 for 30 students scored of 3 to 5 from good to excellence. Figure 14 shows responded users on for interactivity presents 1 score of poor while others are good. Figure 15 shows the responded does AREEE is interesting presents the score of 3, 6 gives the score of 4 and 20 gives the score of 5. Finally, Figure 16 shows the responded-on rating or AREEE shows 6 user rate good, 13 rate every good and 11 present excellent on the score.

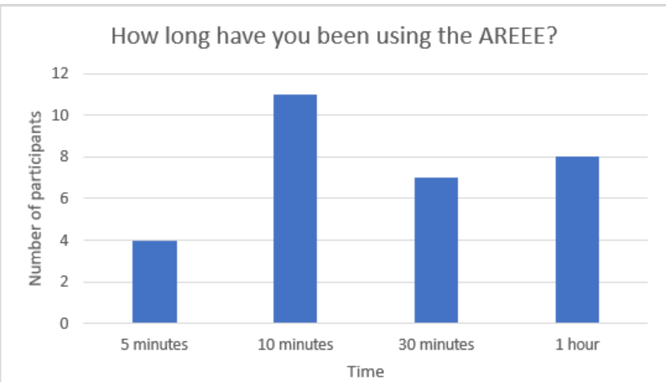


Figure 12: Time using AREEE

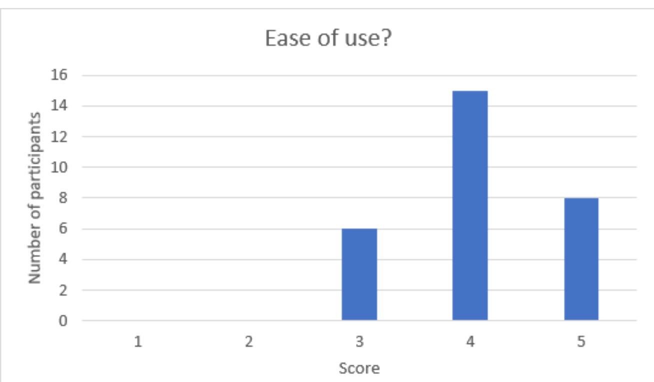


Figure 13: The ease of use

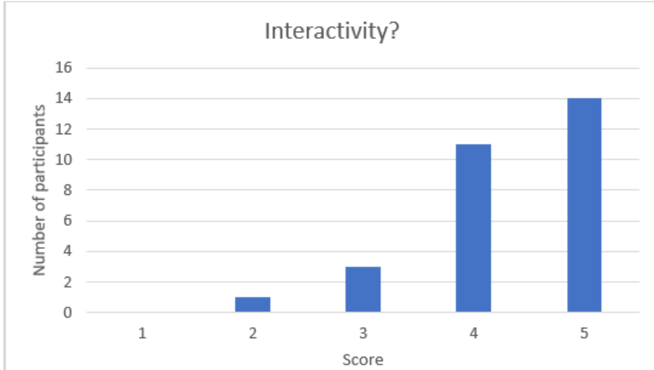


Figure 14:Level of interactivity

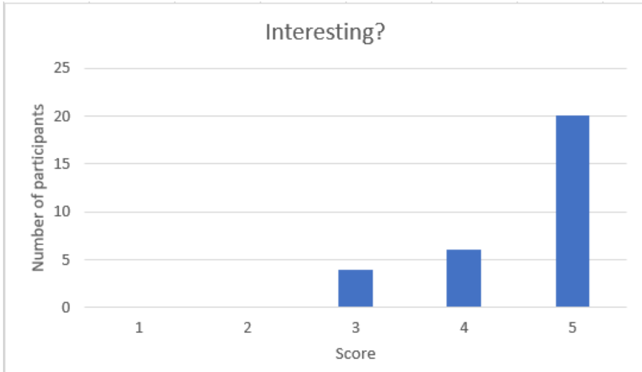


Figure 15 : Level of interestingness

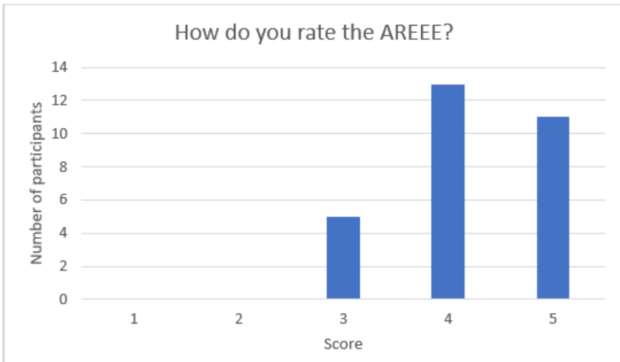


Figure 16: Rating of the AREEE

c. Users experience test for educational experience

Analysis users experience on AREEE test for educational with AREEE is presented. Five Likert scale from 1 to 5 is analyzed from bad to excellence. Figure 17 shows the Preferability compared to learning using conventional ways. Figure 18 shows the response on how easy to learn about engineering equipment compared to conventional ways. Most present good to excellence. Figure 19 shows the response does AREE helps to understand more about the electronics equipment and components present only 1 participant gives the score of 2. Others presents good to excellence. Figure 20 shows the response on helps with group discussion presents 1 participant gives the score of 2 other is good. Finally, Figure 21 shows the response on helps as educational tools for teaching and learning which most presents positive answers.

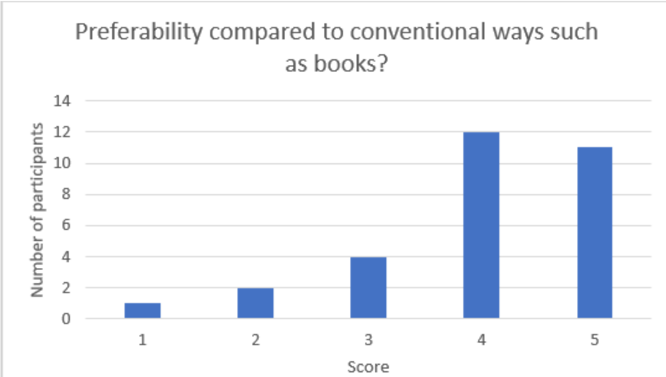


Figure 17: Preferability compared to conventional ways

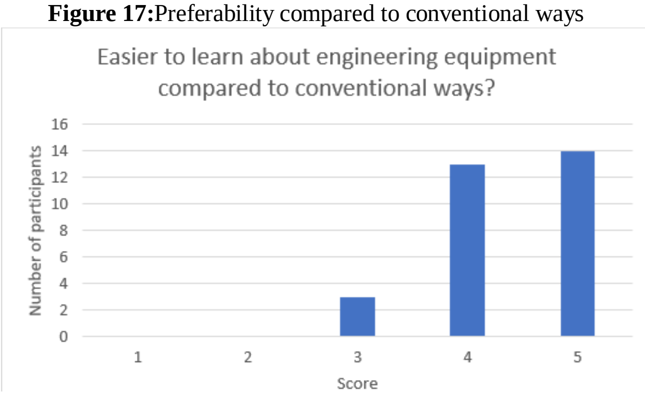


Figure 18: Easier to learn about engineering equipment

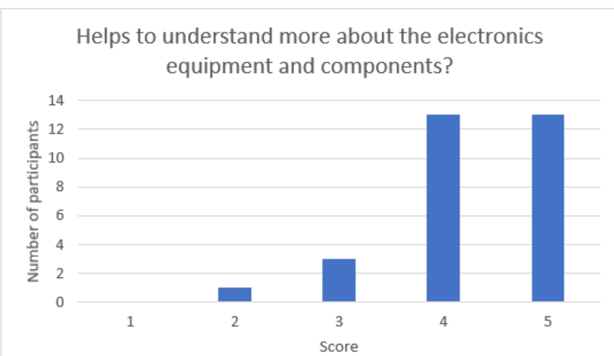


Figure 19: Helps to understand more

Figure 20: Helps with group discussion

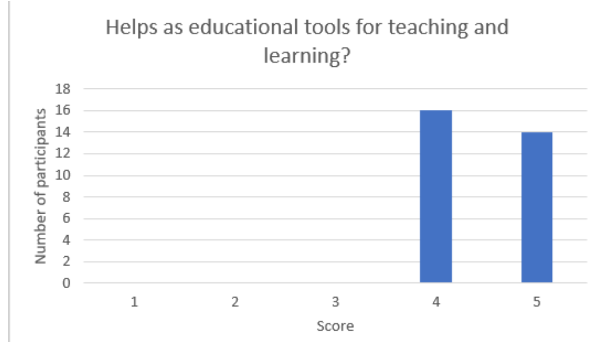


Figure 22: Helps as educational tools

d. Suggestions on AREEE and AR apps

The aim for this section is to get the participants' opinions on AREEE and AR apps. Figure 23 to 25 present responded on questions on suggestion to use AREEE, future educational tools and would AR be replaced the traditional teaching and learning concept are analyzed. Figure 23 presents most students agree the suggestions of AREEE. Figure 24 shows the responded that AR would be the future educational tools where 27 participants have agreed. Finally, Figure 25 shows the responded for AR would someday replace the traditional learning and teaching with 21 participants agreed and others answer may be.

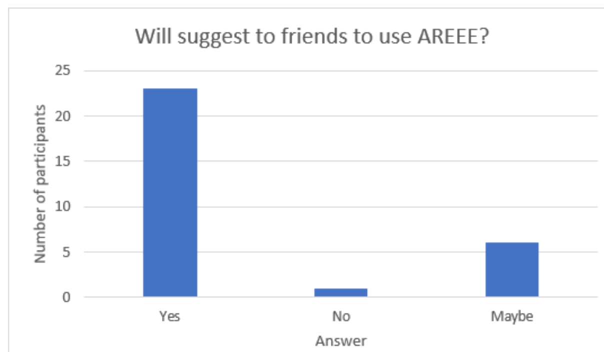


Figure 23: Willingness to suggest AREEE

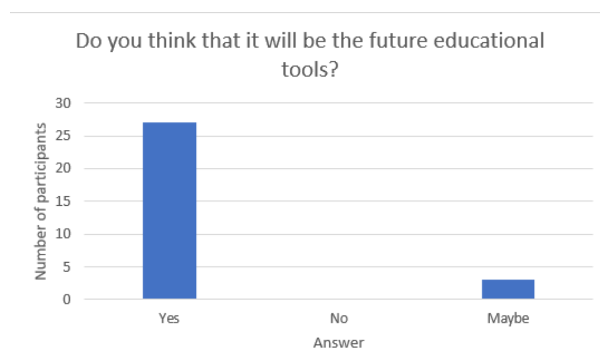


Figure 24: Possibility to be the future educational tools

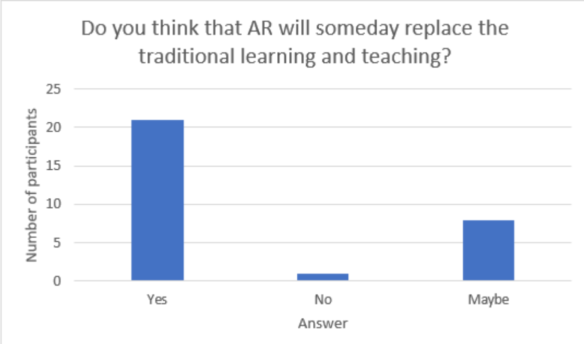


Figure 25: Possibility to replace traditional learning

4.3 Improvement for AREEE

The aim for this section is to get the participants' suggestions on possible improvements for the AREEE. Table 1 shows the suggestions from the participants.

Table I:. Suggestions for improvements

Please suggest any improvement for AREEE	
1.	Add more features
2.	Make more variations for AREEE
3.	Make it usable for Android below 7.0
4.	Should be introduced to the schools as early as Form 1 to enhance the students' imagination and interests on high level technology
5.	More function
6.	System can be accessed from different location
7.	It is good if users not only can view the object but at the same time provides functions that enable the users to modify the objects shown
8.	The set up
9.	Make it more user friendly
10.	Add more equipment

5. CONCLUSION

This has presented a designed of Augmented Reality for Engineering Equipment for Education (AREEE) tool which analyzed the used and future learning concept. AREEE is expected to be significantly more important and widely used in the future learning environment. It can deliver possibilities of new AR technologies in future trends. Its implementation in education is vital to ensure that the learning process is not outdated and up to date with the current technology. Through AR, the students would involve in a more interactive and engaging learning process. Thus, university context is prepared for teaching and learning with technology-mediated narrative and interactive of new AR that is highly engaging among students to academic. The AR applications also would support the current education system for distance learning activity like online classes with virtual learning material which students cannot be interacted with. It also has created an experience to students interacting directly with the engineering equipment, where they can view the 3D model of the equipment from a different angle to get a better look at the equipment. This will create a better learning environment towards supporting the model of Education 5.0.

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