Development of Mobile Augmented Reality Based Media for An Electrical Measurement Instrument

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Abstract. The research aims to develop mobile learning media with augmented reality for electrical measurement instruments. The learner can use this application to improve their skills and knowledge about using electrical measurement instruments correctly. One of the essential skills for electricians is using voltmeter, ammeter, and ohmmeter. The result of measuring they can do some analysis about an issue or troubleshooting the electrical field. From the development research, was produced learning media application product was named ARAVO. ARAVO is an abbreviation of augmented reality of Ammeter, Voltmeter, and Ohmmeter. ARAVO helps learners and even lecturers to simulate the use of electrical measuring instruments by combining virtual objects such as multimeter with the real world. Thus will provide a more visible visualization of how to use electrical measuring instruments before they practice directly with actual measuring instruments. ARAVO is a mobile application that can run on the smartphone platform mobile Android. Into the development of this application must go through several stages before it is ready for use.

1. Introduction

Electrical power installation engineering is one of the expertise programs held at vocational high schools. The purpose of this expertise program refers to the Law on the National Education System number 20 of 2003 article 15 states that vocational education is secondary education that prepares learners to continue their studies in the vocational field or to enter the world of work directly. Specifically, the Electrical Power Installation Engineering Skills Competency is that learners are equipped with skills, knowledge, and competencies in the electricity sector in a professional skills.

The Indonesian National Competency Standards as work competency standards in a field are used as reference competency standards in the development of the Electrical Power Installation Engineering Skills Competency curriculum. These competencies are built on the foundation of normative, adaptive, and productive basic competencies. One of the competencies that must be mastered by prospective professionals in the electrical field is the use of electrical measurement instruments.

In vocational high schools, electric measurement instruments are the competency of expertise in electrical power installation engineering. In this competency, learners learn about the introduction of electric measurement instruments, work principles, measurement procedures, and analysis of measuring...
electrical quantities results. This competency is used as is a primary reference in developing mobile learning augmented reality-based media. The augmented reality technology has been chosen as mobile learning media because of several advantages such as Augmented Reality (AR) is a technology that can change the way people learn and educate. Aside from that, the widespread adoption of mobile devices has sparked a surge of interest in combining the advantages of mobile learning and augmented reality applications [1].

Visual augmentation, in which computer graphics are combined with real-world imagery, is the most popular application of AR. AR blends graphics and video using a handheld computer such as a smartphone or tablet. This is referred to as "handheld camera see-through" [2]. Augmented Reality (AR) promises to be used in educational methods in colleges [3]. Augmented Reality (AR) as mixed and enhanced reality has interesting features for educational purposes; its potential and possibilities can be further expanded when AR systems are designed by connecting different types of technologies. [4].

Augmented reality as a learning medium can also overcome various obstacles in the teaching and learning process in vocational high school. Numerous studies have shown that Augmented Reality (AR) technologies have a beneficial impact on student motivation, learning benefits, communication, engagement, learning behaviors, and enjoyment in all levels of education. In addition, little research has been done on the benefits of AR applications in VET in terms of their impact on addressing various special educational needs, such as learning for disabilities. [5]. During the next few decades, multimedia will cause significant changes in the teaching process, particularly as smart learners discover that they can go beyond the limitations of traditional teaching methods. There is a change in learning from the transmitting or passive-learner model to the experiential or active-learner model [6] In vocational schools, a healthy learning environment learning process is needed to increase students’ interest in learning, reduce stress on students’ cognitive abilities, and improve students’ ability to visualize the material being taught. these things are the impact of the development of augmented reality learning media. Furthermore, the teaching and learning process is more engaging because of the lecturer’s teaching style. Furthermore, the teaching and learning process is more engaging due to the lecturer's style of combining theory and practice at the same time. The use of augmented reality in education not only aids in the creation of a healthy teaching and learning atmosphere, but it also improves learners’ abstract visualization, which is beneficial when performing experiments [7].

2. Design of Mobile Augmented Reality Based Electrical Measurement Instruments

2.1 Development Instruments Introduction

Unity3D is a cross-platform game development framework with a fully integrated professional game engine that includes rendering, physics engine, script engine, lighting mapping, and scene management functionality. Unity3D is primarily used to build mobile games or computer games, and create immersive 3D and 2D environments such as structural visualization, training simulations, and medical visualization. A complete Unity3D software consists of several scenes, each containing a large number of game object and their actions, which are managed by scripts (such as JavaScript, C #, and others). The camera presents and controls what we see in the image [8].

As a mobile application developer platform, Unity does not work alone. There are several development instruments that can be used to create an augmented reality-based mobile application, one of which is the Vuforia SDK. Vuforia is a software development kit developed by Qualcomm with augmented reality capabilities that allow developers to create applications based on augmented reality technology. It recognizes and tracks planar images and 3D objects in real time using computer vision technology. When viewing virtual objects such as 3D models and other media through a mobile device camera, this image registration feature allows developers to position and align them with real things. Virtual objects appear alive and blended into the environmental background. [9].
2.2 The Concept of Learning Media

A study produced a mobile application based on Augmented Reality for electrical measurement instruments in a vocational high school called ARAVO. The apps became a learning media that compiled using AR-based technology. A technology that overlays virtual objects (augmented components) into the physical world is known as augmented reality (AR). These virtual objects then tend to share the same space as real-world objects [1]. Augmented Reality (AR) is a kind of Virtual Environment (VE) or Virtual Reality (VR), as it’s also known. Virtual reality systems completely immerse the user in a synthetic environment, and the user does not perceive the physical world around them. On the other hand, this AR technology takes digital or computer-generated content such as 3D objects, images, audio, or video and adds it to the real world. [10]. This technology is a method of viewing the real world (either directly or through a camera system that creates a visual representation of the real world) and enhancing it visually with computer-generated inputs such as still images, audio, or video, differs from virtual reality in that it enhances a real-world or current scene rather than doing something completely different [11].

The ARAVO is Augmented Reality from Ammeter, Ohmmeter, and Voltmeter. The interface and learning features inside ARAVO are designed to resemble the actual form of using electrical measurement instruments in virtual objects. Mobile AR systems can strengthen cooperative learning and ubiquitous scenes with the help of virtual objects in real environments. Everything in real life can be used as an aid in learning augmented reality to achieve comfort, interactivity, situational awareness, accessibility, and personalization. The ARAVO had five main menus, namely the Home, Competency Standard (SKKD), Play AR, material, and information menu. To understand the work system of the Learning Media of mobile augmented reality-based electric measurement instruments, figure 1 is presented below:

![Flowchart of Mobile Augmented Reality-Based Media Electrical Measurement Instruments](image)

**Figure 1.** Flowchart of Mobile Augmented Reality-Based Media Electrical Measurement Instruments

The Main menu consisted of the being this application purpose made and instructions on how to use the learning media for electrical measurement instruments. The Information menu also can be found
here. The Information menu consisted of a detailed explanation of each button and function in apps. The credits menu shows sources of every part and component 3D model, icon, and pictures that exist inside apps. The competency standard menu is a list of Competencies standards, and Basic Competencies is part of the curriculum vocational high school major of electrical engineering. This menu helps a user understand that the application is part of the competency standard in vocational high school.

The Play AR is the main menu for a Learning Media for electrical measurement instruments with augmented-based technology. There five sub-menus called Resistance measuring with Ohmmeter, DC electric current measuring with Amperemeter, DC voltage measuring with Voltmeter, AC voltage measuring with Voltmeter, and extras.

2.3 Media Design Display
The design of the user interface is one of the most important things while developing a mobile application.

Figure 2 shows the initial view and face of the learning media for electric measuring instruments based on augmented reality. There are 5 main menus displayed, namely homepage, competency, AR play, materials, and information. The workflow for each menu is described in Figure 1 above.
Figure 3 shows the content in each sub-main menu. Every sub-menus was directly connected to the previously programmed AR-based technology in Unity3D. Vuforia AR platform used in this program. The augmented reality method is not marker detection but ground plane detection. The ground plane detection method combines a camera and sensor in smartphones to detect flat surfaces in the environment such as tabletop or floor. After that, an AR program will run and put the 3D model of the electric measurement instrument top on it. The main 3D model virtually for electrical measurement instruments is the multimeter.

A Multimeter is a measuring instrument that can measure various electrical properties like voltage, current and electric resistance. A user can use this menu to simulate how to operate measurement instruments correctly. The Multimeter has simulation can see in smartphones with camera-assisted. As an example measuring DC electric voltage with a voltmeter. As an example measuring DC electric voltage with a voltmeter can see how real is, the voltmeter in a virtual world can use to measure the DC electric voltage as in the physical world perspective.
Figure 4 shows a simulation of using a multimeter to measure voltage with augmented reality technology. The Vuforia Ground Plane allows you to place digital content on flat surfaces in your environment, such as floors and tables. Supports detection and tracking of flat surfaces and also allows you to position content in the air using anchor points [12]. The detection technique does not use markers like AR applications in general but uses the ground plane detection method. The virtual model can access by pointing the camera at a flat area such as a tabletop or floor. The multimeter acts as a 3D model is displayed on the table. The model is visible with the help of a smartphone camera. Each material is equipped with a virtual button that functions to simulate measurements of various electrical quantities.

The multimeter has a selector knob to determine its function and measuring limits. For example, users take measurements of electrical voltage quantities, users define their own measuring limits. The user interface (UI) button on the left side of the smartphone screen is used to control the selector knobs. The multimeter probe cable is moved by pressing a virtual button pin that is visible through the cellphone camera so that the application will pinpoint the target point for measuring voltage. In addition to the virtual button pins, there are virtual previous and next buttons, used to replace the components to be measured.

3. Results

From this development research, was produced a learning media application product named ARAVO electrical measuring instrument. ARAVO is an abbreviation of Augmented-Reality an amperemeter, a voltmeter, and an ohmmeter. This application runs on smartphones that use the Android mobile platform. This research is still limited to the functional test and must through expert judgment to assess the feasibility of the product. ARAVO requires an expert assessment to ensure that the displayed content is worthy of being presented. Two categories of feasibility were assessed, the feasibility of media and material.

Based on the research, the results of the media feasibility assessment by media experts on the visual dimension obtained an average score of 24 and a feasibility percentage of 85.7%. With the eligibility criteria "very eligible". The software dimension assessment score obtained an average score of 33 and a feasibility percentage of 91.7% with the eligibility criteria "very eligible". The usability dimension assessment score obtained an average score of 28.5 and a feasibility percentage of 89.1% with the eligibility criteria "very eligible". The portability dimension assessment score obtained an average score
of 32 and a feasibility percentage of 88.9% with the "very feasible" eligibility criteria. Figure 5 will show the result of media assessment.

![Figure 5](image)

**Figure 5.** The result of media assessment.

The results of the material feasibility assessment by material experts on the material feasibility dimension obtained an average score of 42.5 and a feasibility percentage of 88.5%. With the eligibility criteria "very eligible". The learning dimension assessment score obtained an average score of 21.5 and a feasibility percentage of 89.6% with the “very eligible” eligibility criteria. The functional dimension assessment score obtained an average score of 13.5 and a feasibility percentage of 84.4% with the “very eligible” eligibility criteria. Figure 6 will show the material assessment.

![Figure 6](image)

**Figure 6.** The result of material assessment.

The functional test is installing the application on several android devices from Android version API Level 19 till Android version API level 30. The results obtained are that the ARAVO application can run well on the Android platform and above.
4. Conclusion
The goal of creating augmented reality-based mobile applications is to make learning with smartphones more engaging. This application is a way to overcome the limitations of practical instruments, particularly the competence of electrical measuring instruments. In order to master this competency, the student must first master the understanding and skills of electrical measuring instruments. This electric measuring instrument's augmented reality learning media is predicted to boost a lecturer's efficiency in delivering electrical measuring instrument content that is full of practical learning. Students can digitally replicate the measurement of numerous electrical values such as voltage, resistance, and electric current using a smartphone, just as they exercise with true measuring equipment instruments.

5. References
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