Augmented Reality-Based Instructional Media For Electrical Power Protection Learning

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Abstract. Augmented reality is a technology that combines two-dimensional and/or three-dimensional virtual objects into a real three-dimensional environment and projects those virtual objects in real time. This study was aimed at discussing (1) the development of an instructional media for power system protection learning, especially the fuse cut out, using augmented reality, (2) the appropriateness of the developed media as evaluated by both material and media experts, and (3) the users’ responses toward the developed media. This media was developed using the waterfall model proposed by Pressman, consisting of four main stages: analyzing, designing, coding, and testing. The performance test proved that this media functioned properly (100\%). This media was categorized as “highly appropriate” in terms of the materials presented as evaluated by the material experts with a mean score of 96.5 out of 112. Meanwhile, the media was “appropriate” as evaluated by the media experts with a mean score of 68 out of 84. For the end users of this media, 75\% of them perceived this media as “highly appropriate”, while the rest considered it as “appropriate”.

1. Introduction

The recent development of technology and information increasingly encourages efforts to renew the use of technological advances in the learning process. Teachers are required to be able to use the instructional instruments provided by the school, and it is possible that these instruments are in accordance with the developments and demands of our time [2].

In the digital world, the development of smartphone technology forces the users to always keep updated with the existing developments. Smartphones that are synonymous with cyberspace can now be presented side by side with the real world. This new technology is called Augmented Reality (AR). Researchers continue to try to integrate AR into the real world, leading to a more attractive visualization, so that it can be used as a teaching aid to support the learning process. In the other hand information and communication technology had a big influence on teaching and learning activities and it also made learning interesting for students [1].

The application of good and adequate media is expected to stimulate students’ thoughts, feelings, attention, and learning motivation so that the learning process can run well, energetically, and pleasantly. “The use of instructional media in learning activities can motivate students to learn and make it easier for them to get information” [4].

Android is one of the smartphone operating systems. Android as a Linux-based mobile device that includes operating systems, middleware, and applications [4]. Android provides an open source
platform for developers to build their applications. Android itself was created by Google that collaborates with the open handset alliance. In the same vein, Android is the first open and comprehensive platform for mobile devices [3].

Meirer also classified Android into 3 components, namely as an operating system, as a platform for creating applications, and as a mobile device that runs an operating system [3]. Based on the above opinions, it can be concluded that Android is the first operating system that is open to mobile devices that include operating systems, middleware, and applications. The use of Android is seen as an important application in instructional practices, and thus it needs to be developed in various educational applications such as Edmodo. Android has an architecture that encourages the concept of component reuse that allows users to publish and share activities, services, and data with other applications [3].

Components that support the achievement of learning objectives for Electrical Installation subject are the selection of instructional methods and the use of appropriate teaching materials. The right instructional method concerns how the instructional practices suit the students’ characteristics and what instructional materials can be used to achieve the learning objectives. This process requires a teacher to be able to choose the right instructional method to support the learning process.

The teaching materials used in the learning process should be adjusted to the students’ needs in the classroom during the implementation of learning. The students’ characteristics must be considered for the implementation of the learning process, meaning that the teaching materials are functioned as the primary capital that is used or processed to achieve the targeted objectives. The development of teaching materials should follow the guidelines set in both the core competence (KI) and basic competencies (KD).

From the pre-survey conducted by researchers in the field, it was found that the teachers had tried to enrich the media they used by downloading some animation via the Internet and shared these media with the students so that they could study the materials by themselves at home. However, they did not study these media at home as expected for not all students had a laptop or computer at home.

The Electrical Power Distribution Network subject discusses some sub-materials such as the types of electrical power protection, one of which is Fuse Cut Out (FCO). The materials presented in the textbook only provide explanations and images that are difficult for the students to understand because the illustrated objects do not exist. Therefore, to overcome these shortcomings, new breakthroughs in instructional media need to be made. One of them is by making instructional media software that can be run on an Android smartphone. Based on the description above, it is very necessary to develop teaching materials that will help students to learn actively and independently to facilitate understanding related to the material being studied.

The development of electrical power protection instructional media, especially the Fuse Cut Out based on Augmented Reality, will definitely be very interesting because this media can be presented not only in the form of hardware but also in virtual images through smartphones to enrich students' knowledge and understanding. This learning media consists of a module, an Augmented Reality guidebook, and an application with an .apk extension that can be installed on Android smartphone devices.

The Augmented Reality-Based Fuse Cut Out instructional media is a useful media for students in facilitating their independent learning with the teacher as a facilitator. With this media, not only do the students get a complete picture of the instrument as depicted in the module, but they also get a detailed description of the instrument by using a smartphone to display the results of the AR scanning process.

2. Method

The study employed a Research and Development (R&D) approach and used the linear sequential or waterfall model proposed by Pressman [6]. This study on the development of augmented reality-based fuse cut out instructional media was carried out in state vocational high school SMK N 2 Yogyakarta, starting from July to August 2018.
The research subjects were the lecturers of Electrical Engineering Education Department, Faculty of Engineering, Yogyakarta State University as the materials and media experts, teachers of SMK N 2 Yogyakarta teaching Electrical Installation subject as the material experts, and the students of Grade XII majoring Electrical Installation Engineering as the end users.

The procedure adopted for developing the software in this study was the waterfall model that consists of four stages, including:

2.1 Analyzing needs

Need analysis is a process to represent information, functions, and behaviors that can be translated into data, architecture, interfaces, and components. At this stage, observations and interviews were conducted with the Electrical Installation teachers to get information about the needs for the to-be-developed instructional media.

2.2 Designing

This design serves to facilitate product development in accordance with the analysis of the needs and specifications of the products that have been produced. The design developed at this stage was used as a reference to the program code writing. The design developed in this study included the design of the system architecture and user interface.

2.3 Coding

The design was then developed into an application program in the form of an augmented reality-based instructional media for electrical power distribution network learning. In this study, the software used was Unity 3D and Microsoft Visual Studio 2012 with the C# programming language.

2.4 Testing

After the media development process is complete and the media could be run on an Android smartphone, the next step was black box testing and followed by expert judgment. Black box testing was used to test the performance or functionality of the software developed. While expert judgment by media and material experts was conducted to assess the appropriateness of the instructional media. After the media was evaluated by experts, it was then tested on students to find out their responses to the media.

The data obtained from this study were used to assess the quality of the instructional media produced so that it was worthy of being used as an instructional media. The data obtained were in the form of quantitative data which were then converted into qualitative data. The data were collected through observation and questionnaire. Observations were made to determine the availability of teaching materials and the things needed in developing the modules. However, the observation activities were not guided by observation guidelines.

The questionnaire was used to determine the appropriateness of the developed instructional media. The questionnaire was given to media experts, material experts, and students as the end users. The questionnaire was arranged using a 4-point Likert scale, ranging from highly appropriate, appropriate, inappropriate, and highly inappropriate. Before being used to collect the data, the questionnaire was tested first for its validity and reliability.

The data analysis technique used was descriptive statistics. Descriptive statistics is used to analyze data by describing the data as it is without intending to make any generalization.

The product was tested using a questionnaire. The instrument used was made on a 4-point Likert scale: highly appropriate, appropriate, inappropriate, and highly inappropriate. Likert scale was used to obtain accurate data. Each answer from the respondent was then converted into numbers.
3. Results and Discussion

The development of fuse cut out augmented reality-based (FCO AR) instructional media was driven by the learning problem at a state vocational high school SMK N 2 Yogyakarta, namely the students' low understanding on the Electrical Power Distribution Network, especially the Fuse Cut Out topic, and the monotonous learning techniques that make students less-interested, bored, noisy, and busy playing their smartphone during the lesson. Unquestionably, this later affects the students’ understanding of the materials delivered. To improve the students’ interest in learning and at the same time make it easier for the teacher to deliver the learning materials, therefore, the FCO AR instructional media needed to be developed.

The FCO AR instructional media was developed through several stages, namely analyzing the needs, designing, coding, and testing. Analyzing the needs includes the study of materials to cover, students' needs analysis, and the specification analysis for the learning media to develop. The designing phase includes designing the system architecture using the Unified Modelling Language (UML) and designing the user interface by means of storyboards. The UML design is illustrated by the Use Case Diagram and Activity Diagram. The following is the Use Case Diagram used to build the FCO AR instructional media as presented in Figure 1.

![Figure 1. UML Use Case Diagram](image)

The following is the Activity Diagram as presented in Figure 2.
The design was adjusted to the results of the needs analysis that has been carried out in the previous stage. The results of this design phase were then used in the coding phase for the development of FCO AR application and a book as its supporting book. From the coding phase, software in the form of FCO AR instructional media and a book called Fuse Cut Out was produced. The software was then tested at the testing stage. The tests included the validation by media and material experts to obtain the results of its initial appropriateness. The improvements suggested by there experts were made appropriately. The final stage was the user testing by involving the Grade XII students of Electrical Installation Engineering Study Program at the vocational school SMK N 2 Yogyakarta to find out their perspective on the developed product.

3.1 Instrument Validation

The instruments used in this study were tested for its validity. Instrument validation was carried out by two experts.

3.2 Material Validation

The assessment of the instructional media by material experts was based on three aspects, namely the material contents (MC), learning design aspects (LD), and benefit (BF). Data obtained from the material experts are presented in Table 1.
Table 1. The Results of the Material Validation

| No | Validator          | Aspects | Total | Category | %     |
|----|--------------------|---------|-------|----------|-------|
|    |                    | MC      | LD    | BF       |       |
| 1  | Material Expert 1  | 24      | 18    | 22       | 64    | A     | 76.2  |
| 2  | Material Expert 2  | 26      | 18    | 22       | 66    | A     | 78.6  |
| 3  | Material Expert 3  | 28      | 23    | 23       | 74    | HA    | 88.1  |
|    | Mean               | 26      | 19.7  | 22.3     | 68    |       |
|    | Category           | HA      | A     | HA       | A     |
|    | %                  | 81.25   | 70.2  | 93.1     |       |

Based on Table 1, it is clearly seen that the benefit (BF) aspect has the highest score (93.1%), which was included in the "highly appropriate" (HA) category. It can be understood that the experts suggest that AR technology seems to be appropriate media to assist the students in getting a clear picture of what they learn. Additionally, the material content (MC) was ranked second at 81.25%, which was in the same category, and in the third place was the learning design (LD) aspect with 70.2%, included in the "appropriate" (A) category.

Figure 3. The Percentage of Each Aspect of the Material Validation

3.3 Media Validation

Media validation assessed four aspects, namely: functionality (FC), reliability (RL), usability (US), and visual communication (VC). The results of the validation can be seen in Table 2.
Table 2. The Results of the Media Validation

| No | Validator       | Aspect | Total | Category | %  |
|----|----------------|--------|-------|----------|----|
|    |                | FC     | RC    | US       | VC |     |
| 1  | Media Expert 1 | 21     | 21    | 18       | 40 | 100 | HA | 89.29 |
| 2  | Media Expert 2 | 20     | 18    | 19       | 36 | 93  | HA | 83.04 |
|    | Mean           | 20.5   | 19.5  | 18.5     | 38 | 96.5| HA |

Based on these data, it can be seen that the developed FCO AR instructional media in all aspects of media validation was ‘highly appropriate’. The highest score was found in the usability aspect (92.5%), while the other aspects obtained a percentage between 81% and 86%. The illustration for the percentages is presented in Figure 4.

Figure 4. The Percentage of Each Aspect of the Media Validation

3.4 User Testing

The media that had been validated and declared as appropriate by material experts and media experts were then tested to users to get their responses and input. User questionnaires consisted of three aspects, namely operability, learnability, understandability, and attractiveness were administered to the students and the results are presented in Table 3.

Table 3. Users’ Perception of the Developed Instructional Media

| No | Aspect           | Mean Score | Category          | %  |
|----|-----------------|------------|-------------------|----|
| 1  | Operability     | 20.9       | Highly Appropriate | 87.1|
| 2  | Learnability    | 17.2       | Highly Appropriate | 86.1|
| 3  | Understandability | 10.4     | Highly Appropriate | 86.6|
| 4  | Attractiveness  | 16.9       | Highly Appropriate | 84.6|
The evaluation results on the media found that the attractiveness aspect obtained the lowest score compared to the other aspects, even though they are all still in the "highly appropriate" category. Based on these findings, the researcher conducted a further analysis regarding the lowest score on the attractiveness aspect and found that in the second item was a statement saying, "Appearance is less attractive." This means that the FCO AR instructional media in terms of the application's appearance was less attractive. This was likely due to the misunderstanding of students in reading the questionnaire items as in the first and second item are positive and negative statements that are almost the same.

![The Percentage of Each Aspect of User Assessment](image)

Figure 5. The Percentage of Each Aspect of User Assessment

3.5 The Reliability of the Instrument

Based on the results of the reliability test on the user questionnaires analyzed by the help of SPSS software, the following results were obtained.

| Cronbach’s Alpha | Cronbach’s Alpha Based on Standardized Items | N of Items |
|------------------|-------------------------------------------|------------|
| .808             | .855                                      | 19         |

Based on Table 4, it is apparent that the reliability test on the user questionnaires obtained a score of 0.855 so that the instructional media in the form of an application and module can be said as "reliable".

4. Conclusions

The results of the development of media for learning Fuse Cut Out are in the form of FCO AR application equipped with a module as its support. FCO AR instructional media has the main page that contains (a) profile menu, (b) information menu stating the purpose of the application and references or sources used, (c) help menu containing the application instructions, explanations on menus and websites where the application can be downloaded, and (d) the play now menu that contains the FCO Augmented Reality contents.
The results of the evaluation by material experts based on the material content, learning design, and benefits aspects obtained a total mean score of 68 from a maximum score of 84 or included in the "appropriate" category. As for the results of the media validation based on functionality, reliability, usability and visual communication aspects, the mean score was 96.5 from a maximum score of 112, included the "highly appropriate" category.

As to the results of the user testing on the aspect of operability, learnability, understandability, and attractiveness, the developed instructional media obtained a mean score of 65.4 from a maximum average score of 76, or included in the category of "highly appropriate". Overall, the mean score from all percentages of all evaluation aspects was 75%, suggesting that most of the students perceived that the FCO Augmented Reality instructional media developed was "highly appropriate", while the rest of the students, 25%, rated the learning media in the "appropriate" category.

5. References

[1] Adeyemo S A 2010 The Impact of Information Communication and Technology on Teaching and Learning of Physics International Journal of Educational Research and Technology 1(2) 48-59
[2] Arsyad A 2011 Media Pembelajaran (Jakarta: PT Raja Grafindo Persada)
[3] Meier R 2010 Professional Android™2 Application Development (Indianapolis, Indiana: Wiley Publishing Inc)
[4] Nazir M I J, Rizvi A H and Pujeri R V 2012 Skill Development in Multimedia Based Learning Environment in Higher Education: An Operational Model International Journal of Information and Communication Technology Research 2(11) 820-828
[5] Nazrudin S 2015 Android Pemrograman Aplikasi Mobile Smartphone dan Tablet PC Berbasis Android 2nd Ed (Bandung: Informatika)
[6] Pressman R S 2010 Rekayasa Perangkat Lunak (Yogyakarta: Penerbit Andi)