Augmented Reality As Android Based Learning Media for Wood Field Laboratory Work

B Wulandari¹, G N I P Pratama², N Hasanah¹ and N Yuniarti³
¹Electronics and Informatics Engineering Education Department
²Civil Engineering and Planning Education Department
³Electrical Engineering Education Department
Universitas Negeri Yogyakarta, Indonesia
Email: bektiwulandari@uny.ac.id

Abstract. The objectives of this research were: (1) producing Android-based AR products in the form of a Wood Field Laboratory Work module in Department of Civil and Planning Engineering Education, Faculty of Engineering UNY to facilitate students' visualization abilities; (2) knowing the quality of Augmented Reality products for the Wood Field Laboratory Work module so that it is suitable for use by students and teaching staff; and (3) addressing the learning problems that have so far been present in the Wood Field Laboratory Work. The method used was the Software Development Life Cycle software development model which was described by the v-model waterfall. The v-model included: (1) the stage of specification of user requirements; (2) system architecture design; (3) designing components; (4) writing program codes; and (5) testing. The test results using ISO 25010 indicated that the application of learning media was stated to be very feasible in functional suitability, compatibility, and usability aspects. While from the performance efficiency aspect, the application was considered feasible because there was no memory leak on the device that run it, and CPU usage by five different devices reaches 10%, which is still below the safe limit (15%).

1. Introduction
One of the demands of special skills that must be possessed by students, especially in the Study Program of Civil Engineering Education (CEE), Department of Civil and Planning Engineering Education (CPEE), Faculty of Engineering UNY is wood engineering expertise obtained in the Wood Field Laboratory Work course, where the learning outcomes include students having the ability to design furniture, plan and implement wood construction and finishing wood furniture. Wood Work is very important in the development process, where Wood Work is a construction work involving wood work or wood-using work. Wood work can support/facilitate the development process on the project or to support the contents of the building in the form of furniture/furniture, cabinets, chairs, tables, scaffolding and so on. Currently furniture and building materials made of wood are increasingly needed by the community. And as we know wood is one of the most abundant construction materials in nature and was first used in the history of mankind. Wood is chosen as a construction material in addition to the reason it is easy to get, the price is relatively cheap and has a high aesthetic value.

Based on the observations made, interesting things that were encountered in the Wood Field Laboratory Work course in the wood workshop were (1) students were still difficult to visualize the pictures contained in the Wood Field Laboratory Work module so that students did not have a clear picture when plunging into practice (2) students tend not to read the practice module before...
implementing the Wood Field Laboratory Work (3) the material in the Wood Field Laboratory Work module is quite complex and dominated by reading text. Therefore, the research team felt the need for innovative and creative solutions to learning media in the Wood Field Laboratory Work, Department of CPEE, Faculty of Engineering UNY.

One of the breakthrough solutions offered is to use Augmented Reality (AR). AR is a technology that enables people to visualize cyberspace as a part of the real world that is around effectively so as to make the real world seem to be able to connect with cyberspace and an interaction can occur [1]. AR itself is usually developed on iOS and Android platforms. Both of these mobile operating systems are of course a trend among people all over the world, especially the Android operating system that is booming. This can at least be seen based on data released by IDC (International Data Corporation) where until the third quarter of 2012, Android has controlled 75% of the smartphone operating system market share [2].

In 2016, Tim Cook (CEO, Apple) also stated that AR is a revolutionary technology that has the potential to change the world. He even views the future of AR as important as smartphones in the present. However, AR technology still needs further research and development to optimize its benefits for the community [3]. In the same year, the Vice President of Business and Operations for Google's virtual reality (VR), Amit Singh, said that in 2018 there will be hundreds of millions of Android smartphones that support AR technology [4]. The presence of AR technology is actually welcomed positively by the people of Indonesia, especially in the fields of education, advertising and game applications. As many as 66% of respondents agreed that the AR application can make a real contribution in the future, and to use the AR, the community simply uses a smartphone [5]. Until now, AR has become increasingly popular with the public. According to Senja Lazuardy (Co-Founder & IT Director, Slingshot Group) the reason AR is in demand is because of technological developments, both hardware specifications and system performance on smartphones that have begun to support the functions that exist in AR technology. At present the community thinks AR is only for game and marketing purposes. In fact, AR can also be used for education, engineering, etc. [6].

AR technology will be very appropriate if it is used in a learning module in the form of three-dimensional objects such as in the Wood Field Laboratory Work course in Study Program of CEE that requires the imagination of the user before actually doing the practice. In addition, AR will also help students to be more motivated in the learning process in a non-boring way.

The objectives of this research were: (1) producing Augmented Reality products for the Wood Field Laboratory Work module in Department of CPEE to facilitate student visualization abilities; (2) knowing the quality of Augmented Reality products for the Wood Field Laboratory Work module so that it is suitable for use by students and teaching staff.

2. Research Method

Learning media will be created using the Software Development Life Cycle (SDLC) software development model which is described by the v-model waterfall. According to Pressman [7], the v-model is a variant of the waterfall model. Figure 1 below is a v-model diagram that will be used in the proposed research.
Figure 1. V-Model diagram [7]

The research and development carried out focused on making and testing the quality of learning media software for Wood Field Laboratory Work. The following are the stages of product development using the v-model.

2.1. Techniques for Obtaining User Requirements Specifications
This stage is the stage of understanding what needs are needed by users who will help interpret software features and their functions [7] in designing AR-based Wood Field Laboratory Work learning media in Wood Workshops, Department of CPEE, Faculty of Engineering UNY. In addition to observations, interviews were also needed from the head of the Wood Workshop, Wood Field Laboratory Work lecturer, and technicians to obtain information about the development of media and materials in accordance with the syllabus. After that can be analyzed the list of requests or user requirements (user requirement list) that need to be developed in the making of AR-based Wood Field Laboratory Work learning media.

2.2. Designing System Architecture
The system architecture design stage is the stage to describe the system workflow that will be created. The system architecture design phase is made using Unified Modeling Language (UML) modeling. According to Rosa and Sallahudin [8], UML is a visual language for modeling and communication about a system using diagrams and supporting texts. Designing a system model consists of making use case diagrams, sequence diagrams, and activity diagrams.

2.3. Component Design
The component design stage is the design of the User Interface (UI) design using storyboarding and User Experience (UX) design by looking at the UML diagram that has been created, all of which are tailored to the needs of the user.

2.4. Program Codes
The stage of writing program codes is the stage to apply the design that has been made into the programming language. The software used is Unity 3D with the C # programming language so that applications can be made according to what has been planned and targeted to the user.

2.5. Testing
Testing using ISO 25010 [9] made by the International Organization for Standardization (ISO), uses four of the eight aspects in ISO 25010, they are functional aspects, performance efficiency, compatibility, and usability. The selection of the four aspects is based on the suitability of the testing
aspects of the system contained in the application developed. The functional suitability aspect is the level at which software can provide the functionality needed when the software is used. Performance efficiency aspect is carried out to measure processor and memory consumption. The compatibility aspect aims to find out the extent to which the system, product, or component can be run from one device with different versions of Android and screens. While the usability aspect is the extent to which the software can be used by users to achieve certain goals effectively, efficiently, and meet satisfaction in its use.

3. Result and Discussion
3.1. Stage of Collecting User Requirements Specifications
The results obtained from the data collection stage are related to the conditions and needs of users, they are:

(1) The Wood Field Laboratory Work module consists of 2-dimensional and 3-dimensional images. Nevertheless, students still experience problems in visualizing it because the images are still static. The module also contains more text than images so that students find it difficult to translate existing images.

(2) Even though students have taken theoretical courses before carrying out the practice, students tend not to read the practice module before going straight into practice. This can cause problems in practice such as errors in the sequence of steps - practices that can inhibit or fail in a process of making wood products.

(3) Broadly speaking, Wood Field Laboratory Work aim to provide the basics of using manual carpentry tools/tools. The material provided relates to woodworking tools and assemblies, wood materials, wood joints, product design planning. The most difficult material to understand by students is about wood joints that are often used in woodwork. There are many types of connections that are learned to make beams and boards. The connection is very important role in giving strength to a construction, so that the use and placement must be really tight between one wood and the other wood.

3.2. Stage of System Architecture Designing
This stage is the design stage of AR-based work learning media architecture using the Unified Modeling Language (UML) modeling. System design is described through use case diagrams, sequence diagrams, and activity diagrams.

3.3. Stage of Component Designing
This stage is the stage of designing the learning media interface that will be developed. The interface is designed based on the results of the needs analysis. This media interface design is described using storyboards.

3.4. Stage of Programming
The process of making a program is an application development process from the design results to a programming language so that the results of the design can run according to its functionality. The tags are as follows.

3.4.1. Asset Preparation
The process of making the program begins with installing the 5.6.1f1 unit, Vuforia SDK, Java JDK, and the Android SDK. These tools are tools that must be used to create this application on the Android platform. After that, it was followed by designing markers that functioned as verification tools so that 3D objects could be raised, as well as pivots where 3D objects were located.
3.4.2. Creating an AR Camera Page
The AR Camera page will contain 3D objects. This page is the core of the application. Making 3D objects using special software called Blender 3D. The purpose of using this software is that 3D objects that are created can be as real and as similar as possible to the original. Figure 2 shows an example of making 3D objects for Door With Double Panels using Blender 3D.

![Figure 2. Door with Double Panels on 3D Blender](image)

Then all 3D objects that have been created with Blender 3D are exported to Unity. Unity is software to create a layout of learning media that will be created. Figure 6 shows an example of creating a page layout for displaying 3D objects for Door with Double Panels.

![Figure 3. Door with Double Panels On Unity](image)

Examples of several 3D objects that have been completed for learning media applications are shown in Figure 4, which is a Door with Double Panels. This 3D object consists of several wooden connections that will appear when the user zooms in at certain angles.
When the 3D object Door with Double Panels is zoomed, the door automatically splits into several parts and wooden joints. Each connection can be zoom again so that the user can see more details about the connection.

Figure 6 shows one type of connection, it is the Dove Tail Joint. This construction is usually used on board joints beside drawers and cupboard side boards. This construction helps maintain the stability of wood and furniture from changes in shape due to shrinkage.
3.5. Testing
ISO 25010 is used for testing the software.

3.5.1. Functional Suitability
Functional Suitability Tests are carried out by two experts in the field of multimedia who understand the systematics of software development. The results of Functional Suitability testing are presented in Table 1.

Table 1. Table of Functional Suitability Test Results

| No | Feature                                      | Test Score | Maximum Score |
|----|----------------------------------------------|------------|---------------|
|    |                                              | Examiner 1 | Examiner 2    | Total | Score |
| 1  | Displaying Augmented Reality pages           | 1          | 1             | 2     | 2     |
| 2  | Displaying object description of the Door with Single Panels | 1          | 1             | 2     | 2     |
| 3  | Displaying object description Door with Double Panels | 1          | 1             | 2     | 2     |
| 4  | Displaying the object description of the Door Frame | 1          | 1             | 2     | 2     |
| 5  | Displaying object description of the Dove Tail Joint | 1          | 1             | 2     | 2     |
|    | **Total**                                   | **5**      | **5**         | **10** | **10** |

Based on the results of Functional Suitability testing, the percentage of feasibility is obtained as follows.

\[
\text{Suitability Percentage (\%)} = \frac{\text{Observation Score}}{\text{Expected Score}} \times 100 = \frac{5}{5} \times 100\%
\]

The calculation results of the suitability percentage are 100%, so it can be concluded that in terms of Functional Suitability, the application can be declared "Very Feasible".

3.5.2. Performance Efficiency
Performance Efficiency Test uses one of the tools for testing Android applications, it is Testdroid. Testdroid will display CPU usage and memory by the device you want to use. If memory leak occurs, the tools will provide info. Memory leak is one that can reduce the performance value of an application. If memory leak occurs, the Android system will stop the application (force close) due to lack of memory. The test results are presented in Table 2.

Table 2. Table of Performance Efficiency Test Results

| No | Device     | CPU       | Memory    | Description                                                                 |
|----|------------|-----------|-----------|-----------------------------------------------------------------------------|
| 1  | LG Nexus 5 os 6.0.1 | 8% - 10%  | 143 MB    | CPU usage under 15%, memory leak does not occur                             |
| 2  | Google Pixel 2 | 4% - 8%   | 180 MB    | CPU usage under 15%, memory leak does not occur                             |
| 3  | Samsung J5  | 3% - 10%  | 90 MB     | CPU usage under 15%, memory leak does not occur                             |
| 4  | Sony Xperia Z1 | 6% - 9%   | 90 MB     | CPU usage under 15%, memory leak does not occur                             |
| 5  | Nokia 5    | 3% - 7%   | 150 MB    | CPU usage under 15%, memory leak does not occur                             |
Based on Table 2, the maximum CPU usage by five different devices reaches 10%. This figure is still below the safe limit set by Little Eye (mobile app analysis tools), which is 15%.

Figure 7 shows one of the test results, it is on the Sony Xperia Z1 device. The highest CPU usage reaches 9%, which is still below the safe limit by Little Eye. The test results show that although the five devices tested use large memory for the application, memory leak does not occur, so the application can be declared "Feasible".

3.5.3. Compatibility
Compatibility test is carried out by the method of direct observation at the trial stage of installing, running, and uninstalling applications, on the Android operating system version and different screen sizes.

Table 3. Compatibility Test Result

| No | Device          | Android Version | Screen Resolution | Successful | Failed |
|----|-----------------|-----------------|-------------------|------------|--------|
| 1  | Galaxy S8       | 8.0 (Oreo)      | 2960 x 1440       | 1          | 0      |
| 2  | Galaxy S8       | 8.0 (Oreo)      | 2220 x 1080       | 1          | 0      |
| 3  | Galaxy S7 edge  | 7.0 (Nougat)    | 2560 x 1440       | 1          | 0      |
| 4  | Galaxy S6       | 6.0.1 (Marshmallow) | 2560 x 1440     | 1          | 0      |
| 5  | Redmi Note 2    | 5.0 (Lollipop)  | 1920 x 1080       | 1          | 0      |
| 6  | Oppo A39        | 5.1 (Lollipop)  | 1280 x 720        | 1          | 0      |
| 7  | Andromax R      | 4.1.2 (Jellybean)| 1280 x 720        | 1          | 0      |
| 8  | Motorola Razr   | 4.1.2 (Jellybean)| 960 x 540         | 1          | 0      |
|    | **Total**       |                 |                   | **8**       | **0**  |

Table 3 shows that the application has been successfully running on all tested devices. The application continues successfully on eight devices with a combination of the Android version (version above Jellybean) and a different screen size. Based on the Compatibility test results, the percentage of feasibility is obtained as follows.

\[
\text{Suitability Percentage} (%) = \frac{\text{Observed Score}}{\text{Expected Score}} \times 100 = \frac{8}{8} \times 100\%
\]

The calculation of the suitability percentage is 100%, so it can be concluded that in terms of Compatibility, the application is "Very Feasible".
3.5.4. Usability

Usability testing is carried out by trying applications directly to users who are students of Wood Field Laboratory Work, Study Program of CEE, Department of CPEE, Faculty of Engineering UNY. Students try the applications on each smartphone they have. The comments obtained from this test are that students like this application because of the interesting 3D object design. The most input is given so that the application supports IOS. A summary of usability testing results is shown in table 4. Based on the results of the Usability test, the percentage of feasibility is obtained as follows.

\[
\text{Suitability Percentage} \left(\%\right) = \frac{\text{Observed Score}}{\text{Expected Score}} \times 100 = \frac{1415}{1500} \times 100\% = 94.3\% 
\]

The results of the feasibility calculation are 94.33%, so it can be said that this application belongs to the "Very Feasible" category.

4. Conclusion

Based on the results of the research and discussion, the research team concluded as follows:

(1) This research resulted in learning media applications using Augmented Reality technology for Android-based Wood Field Laboratory Work. Applications are built using the SDLC with the v-model waterfall method. The sequence of stages in this method includes the User Requirements Specification, System Architecture Design, Component Design, Program Code Writing, and Testing.

(2) The test results using ISO 25010 showed that in the functional suitability aspect, learning media applications are declared very feasible, because all functions in the application run 100%. From performance efficiency aspect, the application is declared very feasible, because the application can be run entirely on different screen sizes and Android versions (above the jellybean 4.1.1 version) with a percentage of 100%. From the compatibility aspect, the application is declared feasible because the application runs without a memory leak and CPU usage is below the safe limit (15%). From the usability aspect, the application was declared very feasible, because it obtained a value of 94.33% after being tested by Wood Field Laboratory Work of Study Program of CEE, Department of CPEE, Faculty of Engineering UNY.

5. References

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