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The Development of Augmented Reality (AR)-Based Mobile Learning Media on Routing Concept Subject of Network Infrastructure Administration

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ABSTRACT

This study aims to develop and observe the eligibility level of Augmented Reality (AR)-based mobile learning media for the routing concept in the Network Infrastructure Administration subject for Vocational School students. This research was backgrounded by the students' difficulties in understanding the simple routing procedure due to the less attractive interface and complexity of the learning media they used. The research methodology used in this study is research and development (R&D) with the Alessi & Trollip development model, which is divided into three steps: planning, design, and development. The eligibility level of the learning media was obtained from two types of tests in the development step: the alpha test (subject expert test and media expert test) and the beta test (limited user test). The results of this research show that the Augmented Reality (AR)-based mobile learning media on the routing concept for the Network Infrastructure Administration subject for Vocational School students is already good, more appealing, and can help students understand the routing concept. Based on the data analysis of the alpha-test and beta-test results, the eligibility level of the learning media is "Good" according to the media expert, subject expert, and the limited test by students.

Keywords: Alessi & Trollip, augmented reality, learning media, routing concept

1. INTRODUCTION

The use of technology in daily life is developing rapidly. Based on the Languages ICT statements (Sockett, 2014), using technology became its interest: "This is very important to reflect the change and certainly to increase everyone's level of success in teaching and learning activities." Andresen & Brink (Ratri, Bain, & Amin, 2017) have declared that the goal of using technology like multimedia is to construct meaningful knowledge so that it can be easier to figure out.

The application of technology with the most advanced growth is mobile device usage, i.e., smartphones. In early 2013, based on research conducted by ITU, the estimation of smartphone user growth was around 96% globally and 128% in developing countries (Naqvi & Al Mahrooqi, 2016). This means there are many opportunities to utilize the smartphone as a learning media platform to increase learning quality. Bernard (McKnight et al., 2016) also states that in some research that has been done before, the use of technology shows significant and consistent excellence as a utilization in digital learning.

The implementation of mobile-based learning media can be applied to many school subjects, i.e., the Network Administration Infrastructure subject in the SMK Computer Network Engineering major, which is a part of the C3 level of skills competency. The reason why the Administration Infrastructure Network with routing concept subjects was chosen as the learning material is due to the pre-research questionnaire results that were distributed to 32 11th-grade students of Computer Network Engineering at SMK N 9 Surakarta. Around 77.5% of students had experienced difficulty studying the routing concept subjects, especially in understanding the routing table. Then, only 57.75% of students could understand the routing concept subjects well. Moreover, around 66.875% of students believe that the learning media they have been using to study the

concept routing subject (the mobile and PC versions of Cisco Packet Tracer) is not attractive and too complex, making it very hard to understand. Based on the questionnaire results, it was found that most of the students prioritize the visuals of the learning media they use, or in other words, most of the students have a visual learning style.

Based on the interview results with the subject teacher, most of the students believe that the learning media they were using is visually unattractive and not easy to operate. This made the students easily lose their motivation to learn the routing concept subjects and become more passive in learning activities. Based on the captured questionnaire and interview results, it is necessary to use attractive learning media to create active interactions in the class that fit students' learning styles in understanding the routing concept subjects.

The implementation of mobile-based learning media becomes one of the solutions to attract students' interest in learning the routing concept subject. The mobile-based learning media is expected to help the students learn the subjects more and also to support their learning styles (Suryani, Setiawan, & Putria, 2018). Based on the interview results with the subject teacher, it was found that at least every student has a smartphone to support their learning activities, and most of their smartphones run on the Android OS.

Several types of mobile-based learning media that support students' learning styles are virtual-based learning media such as AR (Augmented Reality), VR (Virtual Reality), or XR (Mixed Reality), which in their use emphasize appearance (visuals). According to Larasati & Widyasari (2021), research has shown that Augmented Reality (AR)-based learning media is more suitable for students with visual learning styles because their understanding level is higher than those with other learning styles. Based on research on the use of game-based learning and Mixed Reality (XR) in IT subjects at several Australian universities, integrating gamification-based learning with the virtualization concept can potentially increase motivation, comfort, and interaction in learning activities. These statements have been supported by research on the use of 360° video with IT-based modeling. By re-creating the material delivered traditionally into virtual scenarios, it is easier for students to explore the material, which can increase motivation and active learning interactions as a first step in conceptualizing a system that in the future can build students' levels of commitment and their motivation to create memorable learning connections (Muñoz-Carpio, Cowling, & Birt, 2020).

In terms of usage cost, the type of virtual-based media that can be implemented is AR (Augmented Reality). AR (Augmented Reality) is a form of displaying objects from the virtual world into the real world (Nuriana, 2016). Compared to VR and XR, AR-based learning media is more efficient in terms of cost since it does not require additional tools such as VR Boxes or other special glasses. Previously, AR-based learning media for the network subject had also been developed by the Mixed Reality Research Lab team from Central Queensland University and Bond University in Australia to study TCP/IP network modeling. The ability of AR (Augmented Reality) media to realize objects from the virtual world into the real world allows learning activities to be less monotonous and more attractive for students to use and learn the material more (Saputro & Saputra, 2015). According to Khan, Johnston, & Ophoff (2019), the use of mobile-based learning media for the 4-dimensional AR-based body anatomy subject has a positive impact on students' learning motivation.

Based on the explanation that has been described before, the solution that can be suggested is creating mobile AR-based learning media. Hopefully, this research can help students improve their comprehension and interest in learning the routing concept subject as a basis for understanding simple routing paths before using more complex learning media (such as Cisco Packet Tracer). Hence, "Development of Android-Based Augmented Reality (AR) Learning Media for the Network Infrastructure Administration Subject on Routing Concepts in Vocational Schools" is chosen as the research title.

2. RELEVANT RESEARCH

Android-based mobile routing learning media was previously developed by Puspitaningrum, Wihidayat, and Hatta (2020) to assist students in SMK in learning static routing material. Based on research conducted by Cowling & Birt (2016) regarding the implementation of Augmented Reality as a learning medium for students in schools studying OSI Layer-TCP/IP Networking material, it was found that students were more enthusiastic about studying the material in-depth using Augmented Reality compared to using 2D learning media. This can be seen from the very high score on the memorability aspect, indicating that students can more easily understand and visualize the TCP/IP model. In a study by Muñoz-Carpio, Cowling, and Birt (2016), the use of Augmented Reality as a learning medium for ICT systems design is more effective than the use of non-AR learning media in student learning activities at school because it has significant advantages in the aspect of pedagogical understanding and requires students to learn collaboratively in its use.

3. RESEARCH METHOD

The type of research used in this study is Research and Development. According to Putra (2016: 15), to produce a product, it is necessary to use a research-based needs analysis to test the effectiveness of the resulting product. The research model used in the development of this learning media is the model developed by Alessi and Trollip. The Alessi & Trollip model was chosen because of its more structured development process with more detailed development activities (Suryani et al., 2018: 153). The following are the stages of the Alessi and Trollip development model.

3.1. PLANNING

The planning stage contains an explanation and description of the media products to be developed. It aims to identify the objectives and scope of the learning media. There are 10 sub-components in this planning stage which are simplified into the following steps.

3.1.1. DETERMINE THE SCOPE OF THE RESEARCH

The result of the research is the development of mobile learning media with Augmented Reality (AR)-based routing concepts, whose material is limited to Basic Competencies 3.3 and 4.3 in the subject of Network Infrastructure Administration and refers to the standards from the CCNA (Cisco Certified Network Associate) book.

3.1.2. IDENTIFY THE CHARACTER OF STUDENTS IN CLASS

Based on the questionnaires filled out by the students, most of them complained about online learning since it was unattractive and the use of the learning media was not very interactive.

3.1.3. DEFINE AND COLLECT SUPPORT RESOURCES

Every student has at least one mobile device (smartphone) to support learning. The smartphones used by most students run on the Android OS (Operating System). Therefore, mobile-based learning media (Android) was chosen as one of the considerations in this research and development.

3.1.4. BRAINSTORM ABOUT THE DEVELOPED MEDIA

To determine the weaknesses and advantages of the learning media to be developed, it is necessary to have an in-depth discussion (brainstorming) between the teacher and the developer. The results of the brainstorming are in the form of the arrangement of materials and features available in the learning media.

3.2. DESIGN

Design is the stage of merging the various content that has been gathered. The design stage is carried out through communication between the developer and the teacher at the school (as the subject matter expert) to create learning media that is easily understood by users. Activities carried out at this stage include collecting material resources, making AR objects and markers, preparing a prototype application, making the interface layout design, and getting approval from both parties (developer and teacher).

3.3. DEVELOPMENT

This stage is the implementation of all the concepts that were created in the design stage. This stage aims to produce a mature learning media product. The process at this stage generally includes product development and product evaluation activities, which are described in detail as follows: a) developing the learning media using the unity application; b) arranging the marker book; c) uploading the learning media; d) conducting the alpha test; e) carrying out early-stage revisions; f) conducting the beta test; and g) making the final revisions.

4. RESULT AND DISCUSSION

4.1. RESULT

This research produced learning media to assist students in understanding the routing concept. This learning media is an Augmented Reality-based application intended for 11th-grade students of SMK TKJ in the subject of Network Infrastructure Administration.

The learning media was tested based on the ISO 25010 standard, with the following aspects tested: functional suitability, performance efficiency, compatibility, usability, reliability, security, maintainability,

portability, and material accuracy. Testing of the functional suitability, performance efficiency, compatibility, reliability, security, maintainability, and portability aspects was carried out by media experts, with portability measured by conducting test cases (testing each application function). The material accuracy aspect was tested by a subject matter expert. Usability testing was done after revising the learning media based on feedback obtained from the media and subject matter experts (alpha test). The usability aspect was tested through a limited user test (or beta test) with students and teachers of the Network Infrastructure Administration subject by distributing the USE Questionnaire.

The alpha-version testing was conducted by media experts and subject experts. Alpha-version testing is intended to test the feasibility of the developed learning media in its early stages. The media expert testing consists of two aspects: functional and portability testing. Functional testing was measured by the following aspects: functional suitability, portability, learnability, operability, attractiveness, adaptability, and installability. The functional test results can be seen in Table 1.

Table 1. Functional test results

Scoring Criteria	Total
Very Bad	0
Not Good	0
Moderate	0
Good	11
Very Good	23

Table 1 shows no results in the "very bad," "not good," or "moderate" categories. The results of the percentage accuracy are shown in Equation (1).

$$\begin{aligned} \textit{Percentage of accuracy (\%)} &= \frac{(11\times4)+(24\times4)}{170} \times 100\% \\ &= \frac{44+115}{170} \times 100\% \\ &= \frac{159}{170} \times 100\% = \textit{93,5\%} \end{aligned} \quad (1)$$

The percentage value of 93.5% indicates that the learning media is very feasible to use. As for the portability aspect, testing was done using test cases. In test-case testing, several devices were used to test each function in the application. Details of the portability test results can be seen in Table 2.

In the material expert testing, the indicators used were accuracy, interest/attention, suitability, and usefulness. The results of the material expert test can be seen in Table 3. The results of the percentage accuracy are shown in Equation (2).

Table 2. Portability Test Results

Conditions	Total
Success	50
Failed	0

Table 3. Subject Expert Test Results

Scoring Criteria	Total
Strongly Disagree (1)	0
Disagree (2)	0
Enough (3)	0
Agree (4)	3
Strongly Agree (5)	7

$$\begin{aligned} \textit{Percentage of accuracy (\%)} &= \frac{\textit{Collected Results}}{\textit{Expected Results}} \times 100\% \\ &= \frac{(4\times3)+(5\times7)}{50} \times 100\% \\ &= \frac{12+35}{50} \times 100\% \\ &= \frac{47}{50} \times 100\% = \textit{94\%} \end{aligned} \quad (2)$$

With a percentage value of 94%, the material in the learning media is in accordance with the material

being taught, with a note for improvement of the material on the learning media as an early-stage revision. The initial product revision of the learning media was based on the advice and input given by media experts and material experts during the alpha test. The following are the details of the revisions to the initial product.

a. Make the buttons more consistent in every scene.
b. Increase the position of the green plane in the third topology scan.
c. Make the markers more attractive, for example, by using a map of a particular building or room.
d. The material should be updated to include the function of the router.
e. The fonts in the learning media should be enlarged.

Beta-testing was carried out by users, including subject teachers and students, after the initial product revision. From the beta testing results, a total score of 82% was obtained from calculation using Equation (3).

$$Eligibility\ Percentage(\%) = \frac{Collected\ Results}{Expected\ Results} \times 100\% = \frac{1379}{1680} \times 100\% = 82\% \quad (3)$$

These results are a combination of the percentages for usefulness (81.6%), ease of use (81.8%), ease of learning (82.5%), and satisfaction (82.6%).

4.2. DISCUSSION

This learning media was developed based on pre-research, which included interviews with subject teachers, distributing questionnaires to students, and a literature review of previous research. Based on the results of these questionnaires and interviews, it was found that some students experienced difficulties understanding the routing concept, including a lack of proficiency in reading routing tables, because the learning media they used was not engaging. The literature review found several studies on the use of Augmented Reality learning media. The results of these studies indicated that AR was able to increase students' understanding and enthusiasm. Research conducted by Cowling & Birt (2016) on the implementation of Augmented Reality for studying OSI Layer-TCP/IP Networking subjects found that students were more enthusiastic about studying the material in-depth with AR compared to using 2D-based learning media. This was evident from the very high score on the memorability aspect, indicating that students could more easily understand and visualize the TCP/IP model. This aligns with research by Muñoz-Carpio, Cowling, and Birt (2016), which states that using Augmented Reality for ICT systems design is more effective than non-AR media because it offers significant advantages in terms of pedagogical understanding and requires students to learn collaboratively.

The development of this learning media followed the Alessi & Trollip research design, which consists of three stages: planning, design, and development. The planning stage for this learning media started with determining the scope of the research, identifying the character of the students, collecting supporting resources, and brainstorming about the media to be developed. The planning stage was carried out by distributing questionnaires to students, studying literature, and conducting interviews with subject teachers. The design phase was then implemented, starting with collecting material sources, creating AR objects and markers, preparing a prototype of the learning media, designing the interface layout (UI/UX), and getting approval from both the developer and the teacher. The final development stage involved writing code in Unity, compiling a marker book, uploading the learning media, conducting alpha tests, making initial revisions, conducting beta tests, and making the final revisions to the learning media.

Based on input from the various tests conducted, the developed learning media has the following advantages and disadvantages:

a) Advantages of the learning media
    1) Attractive user interface (UI).
    2) The Augmented Reality concept is engaging and interactive.
    3) The use of Indonesian makes the application's procedures easier for students to understand.
b) Weaknesses of the learning media:
    1) The learning media could be improved by using markerless-based AR to make it more practical.
    2) A bug exists in the topology scanning feature on devices with 2GB of RAM or less.
    3) The lack of an iOS version limits its reach to a wider range of users.

5. CONCLUSION

Based on the research and development that has been conducted, the following conclusions can be drawn:

a. An Augmented Reality (AR)-based learning medium for routing concepts has been successfully developed to help students understand the material for the Network Infrastructure Administration subject in SMK.
b. The learning medium received a total score of 93.5% in functional testing (covering functional suitability, performance efficiency, compatibility, reliability, security, maintainability, and portability), a score of 94% from subject matter experts for material accuracy, and a usability score of 82% from users. Thus, the learning medium can be categorized as feasible for use.

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