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Utilization of learning media based on augmented reality on design material network topology

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ABSTRACT

Augmented reality (AR) is a growing technology that has great potential in the field of education. This article explores using AR as an interactive learning medium in a secondary education environment. The study involves the implementation of AR in network topology material to enhance student engagement and understanding. This research consists of the design and development of AR applications following the curriculum of the network topology subject at SMK Negeri 1 South Bulango using the waterfall model. The results showed that using AR-based learning media can increase student engagement in the learning process. Three-dimensional visualization of network topology design can improve students' interest and motivation to understand the material better. AR allows students to interact directly with the network topology design model.

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1. INTRODUCTION

The digital revolution has had a significant impact, one of which is in the world of education [1]. In this advanced and rapidly developing 4.0 era, technology has become an important tool to help students learn [2]. Education in Indonesia must continue adapting to technological developments, hoping that innovative technology integration can reduce the gap in access to education [3]. Implementing learning is a learning process or an activity of delivering information from teachers to students [4]. Learning is a series of events that are designed and arranged in such a way as to influence and support the internal learning process of students [5]. Learning can also be defined as increasing students' desire to learn to achieve better learning outcomes [6], [7]. Learning is a complex aspect of human activity that cannot be fully explained. In a complex meaning, learning is a conscious effort from a teacher to teach students to achieve the expected learning objectives [8]. Two elements can affect the learning process: internal components in the form of learning itself and external elements that include things outside of learning.

Quality learning depends on the teacher's initiative, motivation, and creativity [9], [10]. The teacher largely determines the success or failure of achieving learning objectives. In the learning process, teachers must create an interactive, fun, challenging, and motivating teaching atmosphere, providing more space for students to develop their creativity to not feel bored or bored. Teachers who run a good learning design and are supported by adequate learning facilities will make students feel happy and efficiently achieve the expected learning targets.

Education in the digital era increasingly demands innovation in learning methods to increase effectiveness and attractiveness for students. One approach that attracts attention in this context is using

augmented reality (AR) technology as a learning medium. Learning media in the digital era can improve the quality of education and provide convenience for teachers and students in teaching and learning activities [11]. AR as a learning facility combines the real world with virtual elements, creating a more interactive learning experience and presenting information more interestingly, where facilities are expected to make learning more optimal [12]-[14]. The massive growth of technology demands the ability of teachers to adapt to technology, especially in supporting the implementation of their duties. The ability in question is using, providing, and mastering learning media technology. Learning media is essential in keeping the learning process as a medium for teachers to convey material so students can understand it. Using learning media in the learning process can develop interest and increase student motivation [15]. Learning media can also attract students' attention so that they are not quickly bored or bored in learning [16], [17].

SMK Negeri 1 South Bulango is one of the schools at the secondary education level located in South Bulango sub-district, Bone Bolango district, Gorontalo Province. Based on observations and interviews conducted at SMK Negeri 1 South Bulango, especially with informatics subject teachers, it is known that in the learning process carried out by teachers, especially practicum learning for the basics of computer network engineering and telecommunications element on computer network topology material, learning tends to be more monotonous, more teacher-focused and less involving students. In addition, students have limited access to learning materials. The lack of computer facilities as practicum support equipment, coupled with access to material only in the form of books, causes many students to be inactive, so they need help understanding the learning material for computer network topology. Therefore, developing learning methods to stimulate students' network topology knowledge becomes crucial. The application of AR as a learning medium is expected to provide innovative solutions to address these challenges.

The use of AR technology is not new. It has evolved rapidly in various aspects of life, including in the field of education, such as the use of AR to make the learning media a digital practicum [18], [19], and also as an interactive learning medium to the use that helps improve student understanding of learning as well as increase student learning interest [20], [21], in conjunction with the application of the AR technology in learning, enabling the learning process and information delivery to be more interactive, engaging, practical and effective. Through the use by the students in practice, students can run simulations and interact directly with 3D objects, so it is expected to improve the understanding of the concepts and skills of students in computer network topology in particular. Based on the identification of problems as well as the description of the causes of the issues that have been presented, this research will propose an alternative solution that can be done as a solution of the problem that has been described is the application of AR technology as an innovative learning medium in learning the materials of computer network topology in Bone Bolango district.

2. METHOD

AR-based learning media research and development procedure for network topology subjects uses the multimedia development life cycle development model or (MDLC). The MDLC model has six stages: concept, design, material collecting, assembly, testing, and distribution as shown in Figure 1 [22], [23]. The network topology learning material in this learning media includes understanding material and types of network topologies adjusted to the applicable syllabus in SMK. AR technology design includes mobile applications with interactive features, 3D visualization, and integration with lesson materials.

Figure 1. Stages of the MDLC, Luther's model [23]

The six main stages in making this AR network topology material include:

i) Concept: in this case, the goal is to utilize AR technology in learning, especially in network topology material. The primary target users of this application are students and teachers, with the hope that this AR can help students understand the computer network topology model even though they do not see it directly.
ii) At this stage, the initial concept design of the AR display is carried out using the network topology material. We are starting by determining the number of network topologies, colors, and desired display models in the storyboard.
iii) Material collecting: starting from preparing computer specifications that will be used to create AR, installing blender and unity applications, preparing syllabus teaching materials according to school needs, collecting images of network topology types, and preparing audio.
iv) Assembly: the next stage is making AR, following the initial design planned using prepared materials and tools such as the C programming language, Unity Game Engine, and Photoshop.
v) Testing: after the manufacturing stage, the evaluation stage is carried out. In this case, there are two parts, namely the first, black box testing to test for errors in the application before being given to students and the second, direct testing by students regarding the effectiveness of AR in terms of the material loaded.
vi) Distribution is the final stage, where the AR application is stored securely.

3. RESULTS AND DISCUSSION

Learning media realization is the implementation of system architecture design and interface design. Software system architectural design uses UML system model design, while media interface design uses storyboards. This stage of design is derived from a stage of needs analysis done previously; this stage of analysis and design has been described in chapter III. In the realization of learning media, product creation is done using Unity 3D software and Vuforia SDK to support the development of AR. For the encoding process, use Unity software, and for the object resource process, use the applications Corel Draw X7 and Blender.

3.1. AR design appearance

The product is developed as an AR application that can be run on a mobile device with an Android operating system and a network topology AR book containing user instructions, material summaries, and marker images. Below is the result of the realization of the learning media developed.

1) Blender view

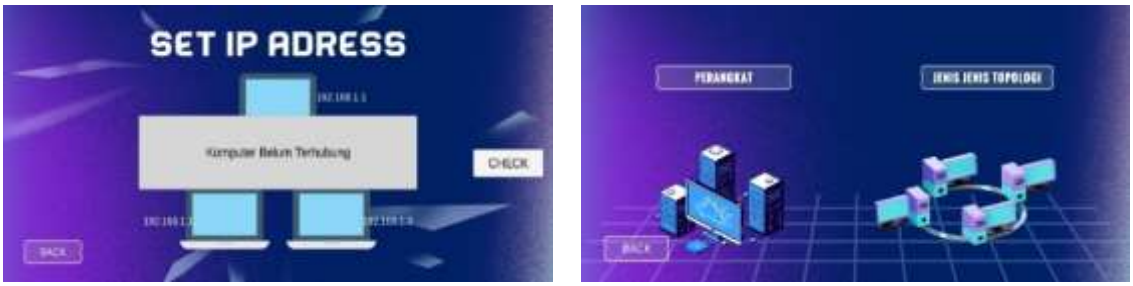
The network topology model is designed using a blender ssee in Figure 2. Figure 2(a) is a design view of one of the network topology models. Meanwhile, Figure 2(b) is the design of the hub. In this section, network objects are arranged by the network topology. Then, the lighting and material settings for the display are also carried out.

(a) (b)

Figure 2. Blender view (a) client dan server and (b) hub

2) View on phone screen

After the rendering process is complete, the network topology display can be seen on the phone screen, see Figure 3. Students can interact with the network topology AR elements. Students can tap the device to display information. As shown in Figure 3(a) shows the game display in AR on the student's cellphone, then Figure 3(b) displays the topology type material.

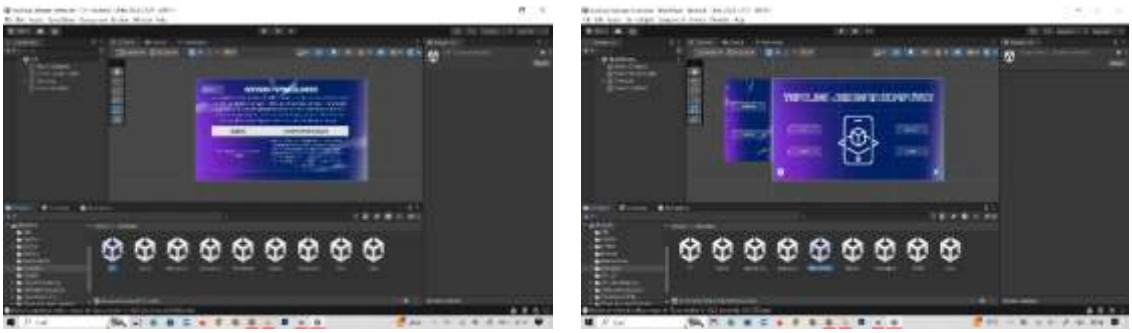


(a) (b)

Figure 3. View on phone screen (a) IP address setting and (b) topology display

3) View on Unity

In addition to Blender, in Figure 4 the development of this AR network topology also uses the Unity application to create an AR application that allows visualization and interaction with the network topology in a natural environment. Unity enables the creation of AR applications that can run on various platforms, including iOS and Android. More details can be seen in Figure 4(a) which shows the display design of learning achievements in the Unity application. Then Figure 4(b) displays the initial display design in the Unity application.



(a) (b)

Figure 4. View on Unity (a) learning outcome information design and (b) initial display design

4) View on Vuforia

This development uses Vuforia, a powerful and widely used AR platform, to create an AR application that visualizes network topology. By using Vuforia with Unity, this application allows users to view and interact with network elements in a natural environment through mobile devices. More details can be seen in Figure 5.

Figure 5. View on Vuforia

3.2. Test results

AR technology was applied through trials in a school involving students and teachers. Positive feedback from users is an indication of the potential success of this technology. The user test phase of the product is the stage of application of the learning media application to the user or user, that is, the student, which is the main target in this research. This user test aims to determine the student's response to the AR learning media product. The user test was conducted in the X class of network computer engineering at SMK Negeri 1 Bulango South on 31 students. The data obtained was a product evaluation by the students in the form of a loading filling of 5 statements with four choice answers. Statements on the lift cover learning design, media display, software, material, and benefits. Students are asked to complete evaluations on the product learning media at this stage. Students are also invited to complete comments/suggestions for further product development. End-user trial data can be seen in the following graph:

Figure 6 shows the students' response to AR-based learning media design, Figure 6(a) show most students thought that the AR learning medium design on the network topology design material was attractive. Meanwhile, Figure 6(b) show students' respon about the shape of the model and the size of the letter used, the students mostly agreed that the models and size are easy to read and have a simple appearance. The fonts used in this application were chosen to improve readability and attract students' interest. The fonts used are easy to read and match the theme of the AR application, be it in displaying instruction text, titles, or additional information.

Animation in AR applications is used to explain complex concepts in a way that is easier for students to understand. Figure 6(c) shows, from the point of view of animation in learning media, most students feel interested and strongly agree that animation within learning media helps in understanding the design material of network topology. Then, the researchers asked about the motivation to study the network topology design material after the presence of this AR media, and the students' responses mainly agreed that they were motivated to research network topological design material using the existing AR media, as show in Figure 6(d). The AR application increases students' learning motivation by presenting the material interestingly and interactively. Positive feedback is given directly through the application to strengthen students' motivation and increase their confidence in understanding the material.

Last, researchers asked about the material presented in the learning media, and the student's responses showed that they strongly agreed that the learning materials presented in the AR media were easy to understand. The materials offered through this AR application are compiled based on the applicable curriculum and adapted to the level of student understanding. The material content is divided into well-structured sections, making it easier for students to follow the learning gradually.

The results of the qualification test show that the AR learning media is capable of achieving the educational goals that have been set. Interactivity and embedded AR elements effectively help students understand complex concepts. It is proven by 59% of trial participants stating that media design is attractive. 48% disagreed regarding the appearance of easy-to-read and easily understood-letters. Regarding animation in learning media, most students (58%) strongly agreed that animation within learning media helped them understand the network topology design material. Then, 45% of students revealed that they were motivated to study through AR. Last seen from the material side, most students (51%) strongly agree that the learning material is easy to understand using AR. Overall, the test results show that AR network topology significantly improves student engagement and understanding in the learning process. The ease of use and the high level of motivation make this application a potential learning tool to be implemented in an educational environment.

The results of simulations and simulation trials on a wide-ranging basis show that AR technology used as a learning medium for network topology is worthy of use. AR is a technology that significantly benefits education [24]. This was supported by Carolina [25], who stated that using AR as a learning medium can improve student learning motivation. Similarly, Buchner and Kerres [26] also said that AR can create a compelling and exciting learning environment. In addition to learning motivation, using AR in learning can also positively affect student learning outcomes [27]. AR-based learning media has proven effective in improving student learning outcomes [28]. Especially in terms of practical material, AR is ideally suited as a safeguard in learning [29]. AR technology has become one of the trends in modern-day innovation [30]. Today, advanced AR technology plays an essential role as a natural learning technology in various fields of education [31].

Although many previous studies have been supported and appropriate, the exciting thing is that the results of this study are different from some existing research, as stated by AlGefari *et al.* [32] that the use of AR in learning has an impact on the cognitive domain of students, especially students' theoretical abilities and digital media addiction in students. Perifanou *et al.* [33] also added that the use of AR in education has many things to consider, such as the lack of digital skills of teachers and students, ethics and security, and the need to increase awareness among teachers of using AR technology in learning.

The use of AR in learning provides practical learning experiences for students. The research results show that students are highly enthusiastic about using AR. Direct observation in the field also shows that students are happy and active in class when delivering material using AR. However, as AlGefari said, it is also necessary to pay attention to the impact of using AR on students. Then, Perifanou *et al.* [33] added that adopting AR in education requires an in-depth study of how teachers respond and view. In practice, when in class, the teacher delivers the material and guides students in learning. This is a limitation of this study. So, this needs to be considered in future research to examine the teacher's perspective on using AR technology in learning more deeply.

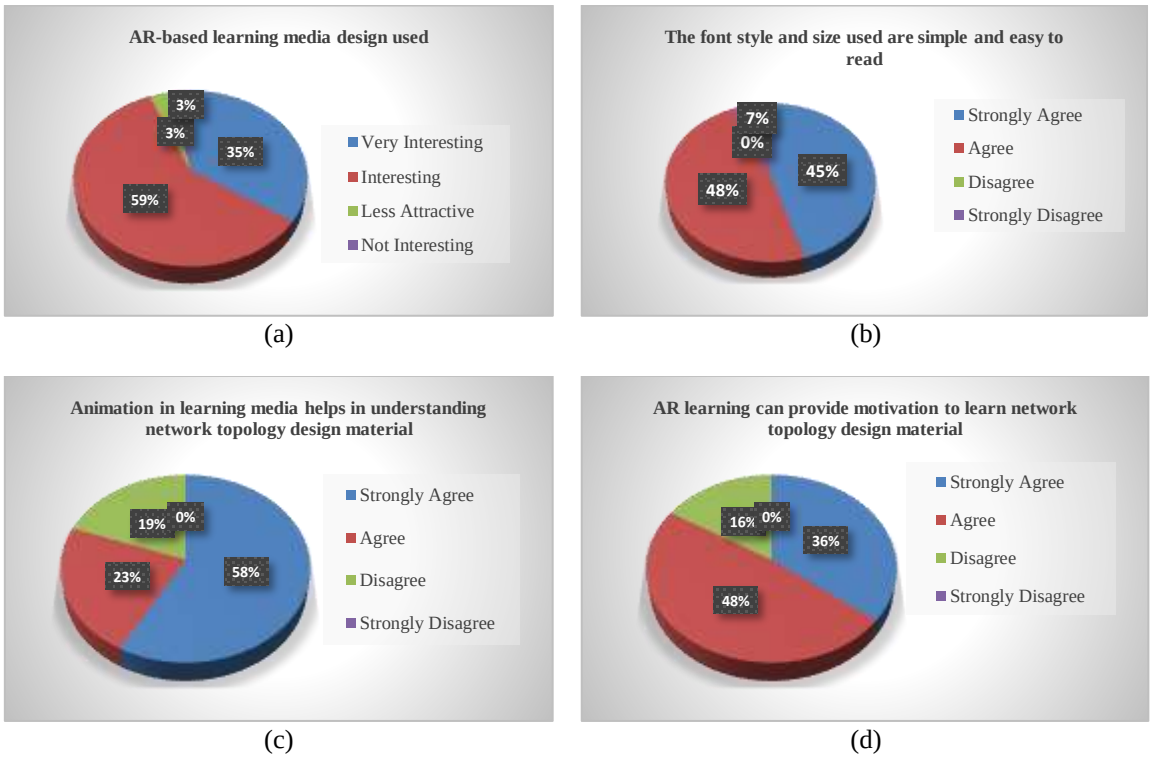


Figure 4. Students' response; (a) student response graphic graphic-related media design, (b) student response graphic related to letter shape, (c) graphic response students related to animation, and (d) student response graphs related to motivation

4. CONCLUSION

AR-based learning media can enhance student involvement in the learning process. The three-dimensional visualization of the network topology design can increase the interest and motivation of students to understand the material better. AR allows students to interact directly with network topological design models. They can explore network components virtually and understand the relationship between devices more practically and interactively. AR enables realistic simulations of different network situations. Students can directly see topological changes' impact on network performance, helping them understand the consequences of the design decisions. However, several things also need to be considered, namely from the cognitive aspects of students, especially theoretical abilities and digital skills for students and teachers, which must be in line with the use of technology in learning.

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