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# Development and Feasibility Testing of Virtual Reality Based Learning Media for Practicum in LAN and Fiber Optic Network Cabling Using the 4D Model

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**Abstract**

This study aims to develop and evaluate the feasibility of Virtual Reality (VR)–based learning media for practicum activities in Local Area Network (LAN) and Fiber Optic (FO) cabling. The method employed was Research and Development (R&D) using the 4D development model, which consists of the Define, Design, Develop, and Disseminate stages. Three-dimensional assets were developed using Blender and integrated into Unity 3D with the C# programming language, then implemented on Oculus devices to produce an interactive and immersive virtual laboratory simulation. The feasibility testing was conducted through validation by media experts and subject-matter experts, as well as user trials employing the System Usability Scale (SUS). The results of expert validation showed a percentage of 88% from media experts and 92% from subject-matter experts, both categorized as highly feasible. User testing involving 20 students yielded an average SUS score of 70 (grade C/OK), indicating that the application is acceptable and suitable for use. The findings demonstrate that the VR media is capable of realistically visualizing the procedures of LAN cable crimping and fiber optic slicing, thereby supporting students' conceptual understanding and practical skills. Therefore, this VR-based learning media is feasible to be utilized as an innovative alternative in computer network practicum learnin.

**Keywords:** 4D model, fiber optic, learning media, local area network, system usability scale, virtual reality.



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## Introduction

The development of information and communication technology in the current digital era has demonstrated significant acceleration, including within the context of education in Indonesia. Digital transformation has continuously influenced various sectors of human life, including the education sector, which is required to adapt to the dynamics of rapidly evolving technological advancements [1]. The integration of technology in learning is no longer an option but a necessity in order to enhance the effectiveness, efficiency, and quality of the educational process. Particularly in the field of interactive multimedia, technological advancements encourage educators to develop more innovative and adaptive instructional methods to achieve optimal learning outcomes [2].

One of the rapidly advancing technologies with significant potential in the field of education is Virtual Reality (VR). Virtual

Reality is a computer-based technology that integrates input and output devices, enabling users to interact intensively with a virtual environment and experience a sense of presence as if they were situated in the real world [3]. VR systems are designed to create a new paradigm in learning through immersive three-dimensional environmental simulations. This approach enables learners to acquire safe learning experiences through representations of real-life situations without posing risks to their physical condition [4]. With its immersive characteristics, VR technology is capable of delivering profound visual and auditory experiences, enabling learners to explore abstract concepts in a more concrete and contextual manner, which ultimately enhances their understanding of the learning material [5].

In the context of vocational education, particularly in Vocational High Schools (SMK) offering the Computer Network and Telecommunications Engineering program, mastery of technical competencies is a highly crucial aspect. One of the compulsory subjects in the curriculum of this program is Basic Networking. This subject encompasses various fundamental aspects of computer network management, including an understanding of network hardware, network topologies, and communication protocols used to connect devices within a limited area (Local Area Network/LAN) [6]. In addition, students also study cabling techniques using Unshielded Twisted Pair (UTP) and Shielded Twisted Pair (STP) cables, which constitute fundamental competencies in computer network installation.

Network cabling material is characterized as technical and procedural in nature and requires hands-on practical skills. However, in practice, the learning process in many educational institutions is still dominated by conventional lecture-based methods. This traditional approach tends to be oriented toward the one-way transfer of information from teacher to students [7]Limited interaction, minimal opportunities for independent exploration, and the lack of variation in instructional media render the learning process less engaging and potentially reduce students' learning motivation. Lecture-based instruction is also considered less effective in fostering students' creativity and critical thinking skills [8]. As a result, abstract and technical materials, such as network cabling, become difficult to comprehend optimally when delivered solely through theoretical explanations without the support of visual and simulation-based media.

The utilization of Virtual Reality–based learning media represents an alternative solution to address this issue. The development of VR media can be carried out using graphic software such as Unity 3D, which is subsequently integrated with Android-based VR headset devices, such as the Oculus Quest [9]. This technology enables the creation of interactive simulation environments that virtually represent real-world conditions. Users are not only able to observe objects but also to interact directly with the elements within the virtual environment. The advantage of VR lies in its ability to provide realistic, participatory, and contextual learning experiences [10]. This is particularly relevant for network cabling material that demands detailed spatial understanding, procedural sequences, and component identification [4].

Several previous studies have examined the use of virtual reality and augmented reality-based technologies in computer networking. Arkadiantika et al. [11] examined the introduction of fiber optic termination and splicing, while Anggraini et al. [12] developing augmented reality (AR)-based media without using virtual reality technology. Another study by Amrulloh and Febriansyah [13] also utilizes AR for fiber optic device recognition. Although these studies demonstrate that artificial reality technology has the potential to support technical learning, the focus of the studies is still limited to the introduction of specific devices or procedures and has not specifically developed VR-based learning media for integrated UTP, STP, and LAN network cabling materials.

Based on this gap, the present study focuses on the development of Virtual Reality–based learning media operated using Oculus devices as an interactive simulation tool for LAN and fiber optic network cabling. This media is designed to facilitate learners' understanding of cabling concepts and procedures through immersive and applied learning experiences. The utilization of VR is expected to optimize the learning process by providing a simulation environment that enables students to practice cabling techniques virtually, minimize the risk of errors in physical practice, and enhance conceptual understanding of network topology and installation [14].

Therefore, the development of Virtual Reality–based learning media in the Basic Networking subject at vocational high schools (SMK) is expected not only to enhance learning effectiveness but also to foster students' motivation and interest in complex technical material. The integration of VR technology in vocational education represents a strategic step in addressing the challenges of digital transformation while strengthening graduates' competencies to align with industry demands.

## Method

This study employed a Research and Development (R&D) approach by adopting the 4D development model proposed by Sugiyono [15] The 4D model was selected because it provides systematic, structured, and relatively straightforward stages for implementation in the development of technology-based instructional media. This model consists of four main phases: Define, Design, Develop, and Disseminate. These four phases were carried out sequentially to produce Virtual Reality (VR) learning media that are valid and feasible for use in network cabling practicum activities.

### a. Define Stage

The define stage aimed to identify and formulate the requirements for the development of the learning media. At this stage, a needs analysis was conducted through a literature review and an examination of previous studies relevant to the development of Virtual Reality–based learning media in the field of computer networking. This analysis included the identification of instructional problems, the characteristics of network cabling practicum materials, and the limitations of the instructional media that had been used thus far.

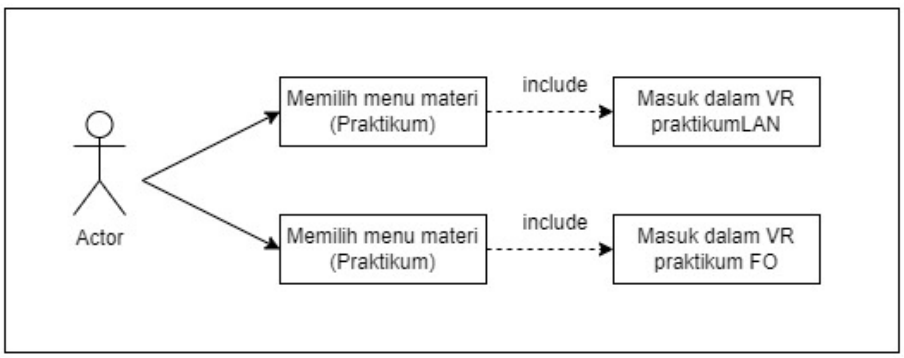
In addition, an analysis was conducted on the competencies that students were required to achieve in the Computer Network Practicum course, particularly in LAN and Fiber Optic cabling materials. The results of the needs analysis served as the basis for formulating the functional and non-functional specifications of the VR system to be developed, including the scope of materials, practicum scenarios, and user interaction features within the virtual environment.

**b. Design Stage**

The design stage was focused on formulating the conceptual and technical design of the learning media to be developed. At this stage, the system design was prepared, encompassing the design of the user flow, user interface, and navigation structure within the virtual environment.

The system design was visualized in the form of a Use Case Diagram illustrating the interaction between the user and the system. Based on this design, users were provided with two primary practicum options, namely the LAN practicum and the Fiber Optic practicum. Each practicum was designed with its own simulation scenario that reflects real operational procedures in cabling activities.

In addition to system design, this stage also determined the software and hardware utilized in the development process. The software employed included Blender for the creation of three-dimensional (3D) assets and Unity as the game engine to construct the virtual environment and manage interaction mechanisms. The C# programming language was used to implement system logic and interactive functionalities. The hardware used for final implementation was an Oculus headset based on the Android platform.




**Gambar 1. Use Case Diagram**

**c. Development Stage**

Tahap pengembangan merupakan proses The development stage involved transforming the design into an operational Virtual Reality–based learning media product. At this stage, three-dimensional visual assets were created using Blender, including models of cables, connectors, network devices, and a virtual laboratory environment. The completed assets were then imported into Unity to be assembled into a comprehensive simulation environment.

Development in Unity included asset integration, the preparation of practicum scenarios, the configuration of navigation and user interaction systems, and the implementation of programming logic using the C# language. The interactive features developed encompassed the selection of practicum types, manipulation of virtual objects, and system feedback in response to user actions.

Upon completion of the development process, the application was exported into a format compatible with Oculus devices. The product installed on the device subsequently underwent an initial testing phase (alpha testing) to ensure that all features functioned in accordance with the design and that no significant functional errors (bugs) were presen.

### d. Disseminate Stage (Spread)

The dissemination stage aimed to evaluate the feasibility and validity of the developed learning media prior to its broader implementation. At this stage, expert validation was conducted involving two media experts and one subject-matter expert from the Department of Informatics Engineering Education. This validation process was intended to assess aspects such as the appropriateness of the content, the quality of the visual design, the clarity of interaction, and the alignment of the media with the learning objectives.

Following revisions based on the experts' feedback, the next stage involved user feasibility testing. The trial was conducted with 20 students from the Informatics Engineering Education Study Program at Universitas Muhammadiyah Surakarta who were enrolled in the Computer Network Practicum course. Data were collected using a questionnaire based on the System Usability Scale (SUS) to measure the system's usability from the users' perspective.

The SUS instrument was selected because it is a widely validated measurement tool for evaluating the usability of interactive systems. The obtained SUS scores were subsequently analyzed to determine the level of acceptance and feasibility of the developed Virtual Reality–based learning media.

## Result and Discussion

The results stage of this study presents the technical implementation of the development of the Virtual Reality (VR)–based learning media as well as the functional analysis of the constructed system. The development process was carried out progressively in accordance with the design formulated in the previous stage, beginning with the creation of three-dimensional assets and culminating in the implementation of the interactive simulation on Oculus devices.

### a. 3D Asset Creation

The initial stage of development involved the creation of three-dimensional (3D) models using Blender software. This process included the design of a virtual classroom, a practicum laboratory, and various supporting equipment such as fiber optic (FO) cables, LAN cables, connectors, and other network devices. A visual representation of this process is presented in Figure 2.

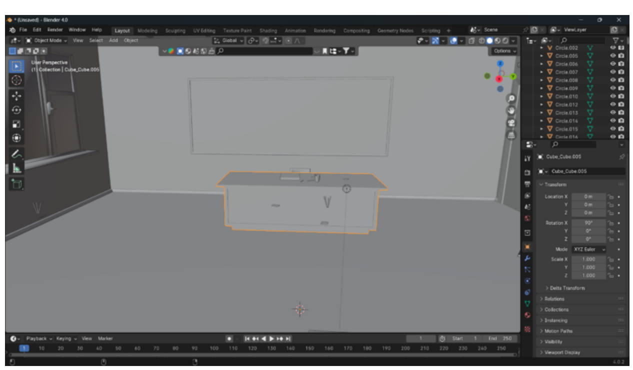


**Figure 2.** Asset Creation Using Blender

Figure 2 illustrates the Blender interface during the modeling process. At this stage, object modeling, material and texture application (texturing), and adjustment of object scale to match real-world proportions were carried out. The creation of realistic 3D assets constitutes a crucial aspect of VR development, as visual quality directly contributes to the level of user immersiveness [16]. A simulation environment that closely resembles an actual laboratory setting enables students to develop a more accurate spatial perception of the layout and use of practicum equipment.

In addition, polygon optimization was performed to ensure that the application maintained stable performance when operated on Oculus devices. This optimization is essential, considering that VR devices possess more limited computational resources compared to desktop computers.

### b. Simulation and Gameplay Development

Once the 3D assets are complete, the next step is to integrate them into Unity 3D to build a complete simulation environment. This process includes scene construction, lighting setup, adding interactive components, and implementing the simulation mechanism using the C# programming language. These steps are shown in Figure 3.

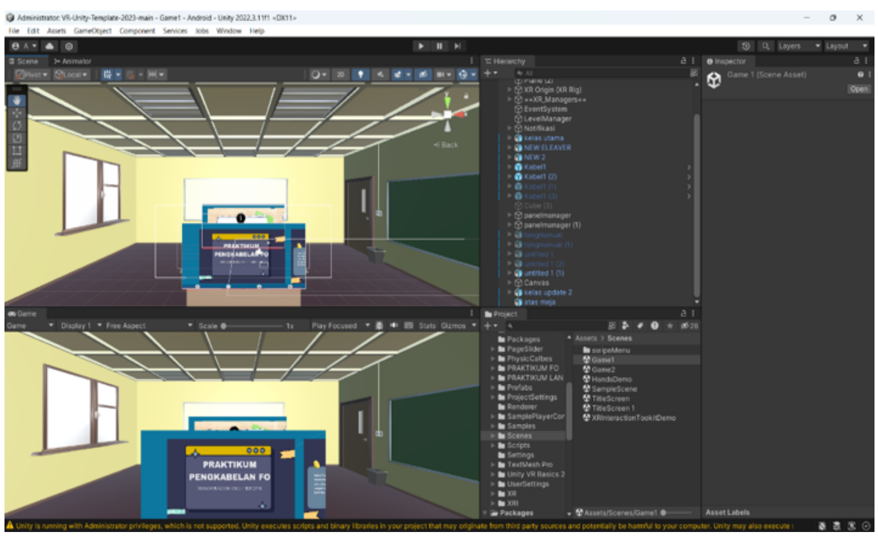



**Figure 3.** Simulation Development

As shown in Figure 3, Unity was utilized as the primary game engine to manage system logic and user interaction. The gameplay mechanism was designed to enable users to select the type of practicum, interact with virtual objects, and receive direct feedback from the system [17]. The developed features include interactive material panels, the creation of virtual practicum tools, and simulation mechanics such as fiber optic (FO) cable slicing and LAN cabling processes.

The integration of the C# programming language facilitated the implementation of event-based interaction controls, such as object grabbing, component assembly, and procedural step validation. The system was designed to provide responses when users perform incorrect procedures, ensuring that the application functions not only as a visualization medium but also as a procedural simulation–based learning tool.

**c. Implementation on Oculus Devices and Main Interface**

Once the development phase is complete, the application is exported in a format compatible with Oculus devices. Testing is conducted to ensure all features work properly in a real-world VR environment. Implementation on Oculus devices aims to maximize the user's immersive experience through stereoscopic displays and a motion tracking system.

The initial application interface is shown in Figure 4, which displays the main menu, which serves as the user's navigation cente.

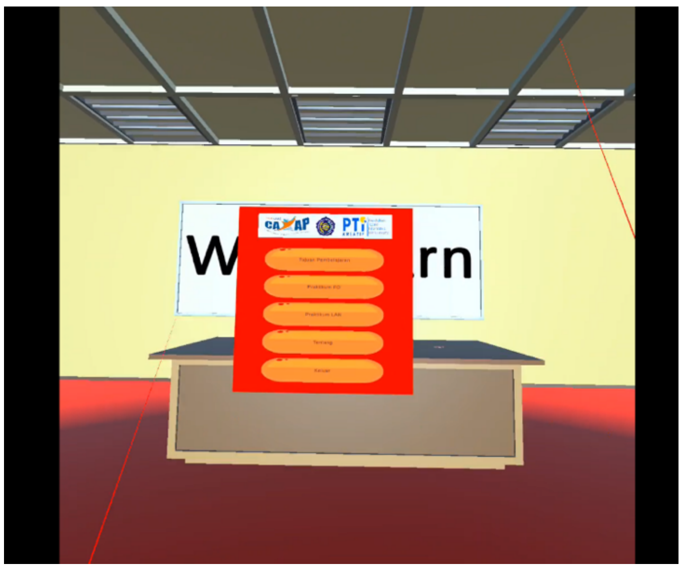


**Figure 4.** Home Page

Figure 4 illustrates the main menu interface, which consists of five primary buttons: Learning Objectives, FO Practicum, LAN Practicum, About, and Exit. The interface design was intentionally developed to be simple and intuitive in order to minimize users' cognitive load. A clear navigation structure assists students in understanding the application flow without requiring complex instructions.

The "Learning Objectives" menu provides information regarding the competencies to be achieved, enabling users to establish a clear orientation before starting the simulation. The "About" menu presents information about the developer and a brief description of the application. This approach demonstrates that the application is designed not merely as a simulation tool, but also as a structured learning medium.

**d. Fiber Optic Practical Simulation**

If the user selects the FO Practical menu, the system will direct the user to the virtual fiber optic laboratory room as shown in Figure 5.


**Figure 5.** Fiber Optic Lab

Figure 5 presents the three-dimensional FO laboratory environment, which enables users to simulate the slicing process of two fiber optic cables. The simulated procedures include cutting, splicing, and arranging the cables in accordance with standard practical guidelines. To support comprehension, the application also provides tutorials in the form of images and videos that can be directly accessed within the VR environment [18].

The availability of these multimodal tutorials strengthens the experiential learning approach. Students not only read instructions, but also observe demonstrations and immediately practice them within the virtual environment. Consequently, the learning process becomes more interactive and contextual compared to conventional lecture-based methods.

**e. Implementation of LAN Practical Simulation**

In addition to the Fiber Optic (FO) simulation, the developed Virtual Reality (VR) application also provides a LAN Lab feature. When users select the "LAN Lab" menu on the main page, the system will direct them to a virtual LAN laboratory environment, as shown in Figure 6.

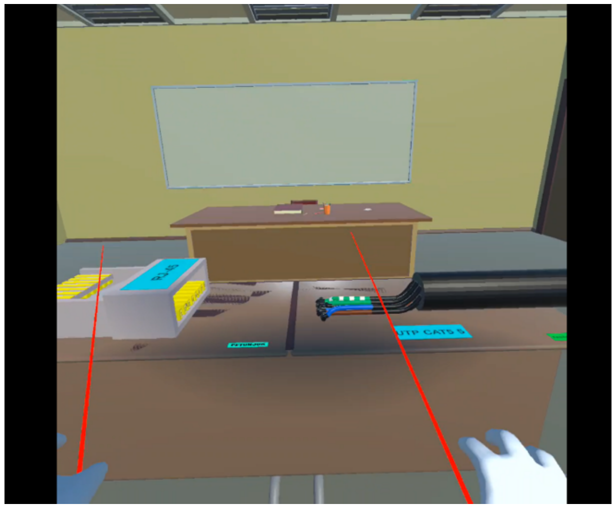


**Figure 6.** LAN Practicum

Figure 6 illustrates the LAN laboratory represented in a three-dimensional environment designed to resemble an actual computer networking laboratory. In this simulation, users practice UTP cable crimping by determining the correct cable color sequence according to established standards, such as T568A or T568B. The interaction mechanism is designed based on object manipulation, allowing users to select cables, arrange the color order, and virtually insert the cables into the RJ-45 connector.

The application also provides supporting tutorials in the form of videos and images that can be accessed directly within the VR environment. This feature is intended to provide instructional scaffolding, enabling students not only to practice through trial-and-error but also to receive systematic procedural guidance [19]. This approach integrates visual, kinesthetic, and auditory aspects within a single learning ecosystem, which theoretically can enhance retention and conceptual understanding.

From a pedagogical perspective, VR-based crimping simulations allow students to understand procedural sequences more concretely compared to merely observing classroom demonstrations. Errors in cable arrangement can be immediately identified by the system, providing instant feedback. This mechanism supports experiential learning and error-based learning, both of which have been shown to be effective in improving procedural competence.

### f. Media Expert Validation

Product quality testing was conducted through expert validation involving two lecturers from the Department of Informatics Engineering Education, Universitas Muhammadiyah Surakarta. The instrument used was a Likert-scale questionnaire consisting of 19 statement items covering three main aspects: (1) instructional design, (2) visual communication, and (3) software aspects.

The instructional design aspect assessed the alignment of the media with learning objectives, the organization and flow of content presentation, and the clarity of instructions. The visual communication aspect evaluated layout arrangement, display consistency, text readability, and the visual quality of 3D objects. Meanwhile, the software aspect examined system stability, ease of navigation, interaction responsiveness, and compatibility with the Oculus device.

The validation results indicated a feasibility percentage of 88%, which falls into the "very feasible" category. This score demonstrates that, both technically and visually, the application meets the quality standards of interactive learning media. A percentage above 85% indicates that the design and system implementation align with the fundamental principles of digital instructional media development.

### g. Validation by Material Experts

The subsequent validation was conducted by a lecturer responsible for the Computer Networks course, serving as the subject matter expert. The instrument consisted of 16 statement items covering two primary assessment aspects: instructional design and visual communication in relation to the substance of the material.

The evaluation focused on the alignment of the content with the curriculum, the accuracy of practicum procedures, the correctness of LAN and Fiber Optic cabling concepts, and the relevance of the simulation to actual laboratory practices. The validation results showed a percentage of 92%, which is categorized as "very feasible."

This score indicates that the material presented in the VR application is consistent with the competency standards and learning outcomes of the Computer Network Practicum course. The subject matter validation serves as an important indicator that the simulation is not only visually engaging but also conceptually and procedurally accurate.

### h. User Testing

The next testing stage was a user feasibility test involving 20 students taking a computer networking practicum. The instrument used was the System Usability Scale (SUS), which consists of 10 statements with a five-level rating scale, as described by Adhantoro et al. [20].

The summary of respondents' responses is presented in Table 1. Based on the SUS score calculation, a cumulative total score of 1393 was obtained. This score was then divided by the number of respondents (20 students), resulting in an average score of 70.

**Table 1. SUS Questionnaire Results**

| No | Respondents | Assessment Items | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Q9 | Q10 |
| **1** | Respondent 1 | 5 | 1 | 5 | 2 | 5 | 5 | 5 | 1 | 5 | 4 |
| **2** | Respondent 2 | 5 | 1 | 5 | 2 | 5 | 5 | 5 | 1 | 5 | 4 |
| **3** | Respondent 3 | 4 | 3 | 3 | 2 | 4 | 3 | 5 | 4 | 4 | 2 |
| **4** | Respondent 4 | 5 | 5 | 5 | 5 | 5 | 2 | 5 | 5 | 5 | 5 |
| **5** | Respondent 5 | 4 | 4 | 4 | 5 | 3 | 4 | 5 | 4 | 4 | 2 |
| **6** | Respondent 6 | 5 | 5 | 5 | 3 | 5 | 5 | 5 | 5 | 5 | 4 |
| **7** | Respondent 7 | 4 | 4 | 4 | 5 | 5 | 5 | 5 | 4 | 3 | 5 |
| **8** | Respondent 8 | 5 | 1 | 5 | 3 | 5 | 1 | 5 | 1 | 5 | 5 |
| **9** | Respondent 9 | 4 | 3 | 4 | 5 | 4 | 3 | 4 | 2 | 3 | 5 |
| **10** | Respondent 10 | 4 | 2 | 4 | 2 | 5 | 3 | 4 | 1 | 5 | 2 |

| No | Respondents | Assessment Items | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Q9 | Q10 |
| **11** | Respondent11 | 5 | 1 | 5 | 2 | 5 | 2 | 5 | 2 | 5 | 2 |
| **12** | Respondent 12 | 5 | 1 | 3 | 3 | 5 | 2 | 4 | 1 | 5 | 2 |
| **13** | Respondent 13 | 3 | 2 | 4 | 4 | 4 | 3 | 5 | 2 | 4 | 4 |
| **14** | Respondent 14 | 5 | 2 | 4 | 3 | 4 | 2 | 4 | 2 | 4 | 4 |
| **15** | Respondent 15 | 5 | 3 | 3 | 3 | 4 | 4 | 5 | 2 | 4 | 4 |
| **16** | Respondent 16 | 5 | 2 | 5 | 3 | 4 | 3 | 5 | 2 | 4 | 3 |
| **17** | Respondent 17 | 5 | 2 | 4 | 3 | 5 | 3 | 4 | 2 | 4 | 3 |
| **18** | Respondent 18 | 5 | 2 | 4 | 4 | 4 | 3 | 4 | 2 | 4 | 3 |
| **19** | Respondent 19 | 5 | 2 | 5 | 3 | 4 | 2 | 5 | 2 | 4 | 3 |
| **20** | Respondent 20 | 5 | 4 | 4 | 2 | 4 | 3 | 5 | 4 | 4 | 2 |

In the standard SUS interpretation, a score of 70 falls into grade “C” or “OK.” This indicates that the application has achieved an acceptable level of usability, although it has not yet reached the “Excellent” or “Best Imaginable” category. The score suggests that, in general, students perceive the application as easy to use, with fairly clear navigation and understandable interaction without significant difficulty.

Nevertheless, this result also indicates room for improvement, particularly in enhancing the overall user experience (UX). Several aspects that could be optimized include control responsiveness, simplification of menu navigation, and improvement of visual comfort for prolonged use.

Overall, the development of the VR-based learning media for LAN and Fiber Optic cabling practicum demonstrates positive results. Media expert validation (88%) and subject matter expert validation (92%) confirm that the application is highly feasible for use as a learning medium. The SUS test result, with an average score of 70, indicates that the application is accepted by users and possesses an adequate level of usability.

These findings are consistent with Kustandi et al. [14], who stated that the integration of VR in learning can enhance students’ motivation and conceptual understanding. Furthermore, the results support the study by Parulian and Mardiyati (2021), which emphasized the effectiveness of VR as an alternative medium for simulation-based learning.

Compared to the research conducted by Arkadiantika et al. [11], which focused solely on fiber optic termination and splicing, this study offers a broader scope by covering two materials simultaneously: LAN and Fiber Optic cabling. In contrast to studies by Alkhabra et al. [21] and Soraya [22], which utilized Augmented Reality (AR) technology, this research provides a higher level of immersion through the use of Virtual Reality. VR technology enables users to be fully immersed in a virtual environment, thereby creating a deeper and more engaging learning experience.

However, when compared with Ahn & Chen's research [23] while emphasizing comprehensive immersive aspects across various learning concepts, this research is still limited to network cabling material. Therefore, further development can be directed at expanding the scope of the material, adding advanced simulation scenarios, and integrating automatic performance-based assessment features.

## Conclusion

Based on the results and discussion presented, it can be concluded that the development of Virtual Reality (VR)-based learning media for LAN and Fiber Optic (FO) network cabling practicum using the 4D development model (Define, Design, Develop, Disseminate) has been systematically implemented and has produced a feasible product for instructional use.

During the development stage, the media was designed through the creation of three-dimensional assets using Blender and integrated into Unity 3D with the support of the C# programming language. The application was then deployed on an Oculus device, enabling the creation of an immersive and interactive virtual laboratory environment. The developed features include LAN practicum simulation (UTP cable crimping) and FO practicum simulation (fiber optic cable slicing), both supported by tutorial materials in the form of images and videos to enhance students' procedural understanding.

The media expert validation results showed a feasibility percentage of 88%, categorized as "very feasible." Meanwhile, validation by the subject matter expert obtained a score of 92%, also classified as "very feasible." These findings indicate that the developed media meets quality standards in terms of instructional design, visual communication, software performance, and alignment of content with learning outcomes.

User feasibility testing using the System Usability Scale (SUS) involving 20 students resulted in an average score of 70, which falls into grade "C" or "OK." This suggests that the application has an acceptable level of usability and is suitable for implementation in learning activities, although improvements are still needed, particularly in terms of user experience (UX).

Overall, the developed VR-based learning media provides an interactive simulation that supports practicum learning in a safer, more flexible, and immersive manner. Three-dimensional visualization and direct interaction with virtual objects help students understand network cabling concepts and procedures more concretely compared to conventional lecture-based methods. Therefore, the integration of Virtual Reality technology into computer networking practicum can serve as an innovative alternative to enhance the quality of learning, particularly in technical and vocational education.

Future research is recommended to expand the scope of materials, incorporate performance-based assessment features, and further enhance interactivity and user comfort to achieve higher usability levels and greater instructional impact.

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