

DEVELOPMENT OF VIRTUAL REALITY FOR OPTICAL FIBER SPLICING SIMULATION

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Abstract

This study aims to determine the design and evaluation of content and media experts in the development of Virtual Reality for Optical Fiber Splicing Simulation. The research method used is Research & Development with the Multimedia Development Life Cycle (MDLC) model which consists of concept, design, material collecting, assembly, testing, and distribution stages. This Virtual Reality development uses the Unity application in making applications with the Oculus Quest 2 device. The data collection process begins with interviews with educators about the learning that takes place, and the difficulties experienced. At the testing stage, Blackbox Test, Content Expert Test: 1.00 Validity Coefficient, and Media Expert Test: 1.00 Validity Coefficient. Virtual Reality for Fiber Optic Splicing Simulation offers simulation before implementing splicing in real. By taking characteristics of life such as laboratories, educators, and fiber optic practicum tools. Virtual reality can provide situations and conditions for students to practice Optical Fiber Splicing by entering a virtual laboratory in cyberspace. The learning experience in Virtual Reality that provides a sense of immersion in a virtual environment using Full Hand Interaction that applies the Hand Tracking function in Oculus Quest 2. Based on the overall test, the development of Virtual Reality for Optical Fiber Splicing Simulation is feasible to use and distribute to target students.

Keywords : Virtual Reality, Simulation, Optical Fiber Splicing

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INTRODUCTION

Learning is explicitly a process of exploring knowledge, mastering skills, and shaping the character of students by forming their own concepts and knowledge of what has been learned [1]. The concepts that have been created have indicators of right and wrong because human interpretation varies for each person in terms of speed, accuracy, and cohesiveness. Therefore, mentors are needed to guide learners in learning so that the concepts that have been made do not run contrary to reality or the intent of the knowledge. The presence of mentors in learning in general is to ensure that all students can understand and be safe in practice [2]. The guidance and learning that teaches students in reasoning and discovering a new concept or knowledge, namely, practicum. Practicum provides opportunities for students to play an active role in seeking knowledge, implementing concepts, and skills through structured problems and procedures in achieving final results [3].

Practicum is a crucial part of learning because it serves as a test of a principle or

concept that has been learned. Practices are inherently dynamic and interconnected to provide a unique and important perspective [4]. When associated with learning practices, practice is an activity to train science process skills and practitioner character in conducting investigations related to concepts and principles. The validity of practicum criteria shows the validity of the implementation of concepts that can be in the form of observation, implementation, logical reasoning, and discovering new things. The application of relevant tools and processes can improve teaching practices and facilitate learning improvement [5].

One of the courses in the Faculty of Engineering and Vocational Education Informatics Education Study Program that often orbits on practicum is Network Administration. Network administration centers on managing network administration starting from basic concepts and theories about computer networks, practice of basic computer network knowledge, and implementation of network settings and utilization of services commonly used in networks. The practicum in this subject

prevents the level of errors in the application of principles and concepts, especially in the Fiber Optic Splicing sub-learning. Fiber optic cable is a network media that can transmit light [6]. This optical fiber has a longer range than 550-meters to hundreds of kilometers, is resistant to electromagnetic interference and can send data at high speeds [6]. Fiber Optic Cables are often found in connecting telecommunications networks such as cable television, internet, mechanical inspection, medicine, networks between buildings and even networks between islands. Explicitly fiber optic splicing is a technique for combining two optical fibers to form an optical link [6]. Fiber Optic Splicing Practicum is often held in order to provide a natural situation for students to be able to implement theories, techniques, and honing or reasoning so that students' qualifications are formed in the field of practice.

Based on interviews with educators who teach Computer Network courses in the Informatics Engineering Education Study Program, learning related to Optical Fiber Splicing followed by students is still unable to implement the skills and procedural knowledge of Optical Fiber Splicing when meeting with real tools. Learning still uses conventional methods, namely video playback to understand the use of fiber optic tools as a substitute for fiber optic practicum because there is still no availability of media & practicum aids to replace Optical Fiber Splicing. This means that it still has not touched the realm of practice. Therefore, the error rate will be higher if students will apply the Fiber Optic Splicing technique.

Based on this, the solution offered is to apply Virtual Reality for simulation practicum before implementing Optical Fiber Splicing in real. By taking characteristics of life such as laboratories, educators, and fiber optic practicum tools. Virtual reality can provide situations and conditions for students to practice Optical Fiber Splicing by entering a virtual laboratory in cyberspace. This is much better than video playback, because the use of videos still does not provide practice related to Optical Fiber Splicing. Virtual reality is explicitly a virtual world formed by replicating the reality that exists in the world [7]. Virtual reality is a medium with tremendous potential in the combination of hardware and software that together create a three-dimensional or 3D digital environment and users can interact with it [8]. This technology allows Virtual Reality users to interact with the world and the content in it. Virtual reality is often used as a medium of

learning and simulation in various fields because it can provide a detailed description of a procedure [9], [10]. Procedures may differ according to the respective field, such as in property sales, Virtual Reality can be used in weighing the house to be built or the house to be bought [11], [12]. Virtual reality allows users to experience and observe virtual environments with high engagement, which can improve workplace learning behavior, professional knowledge and problem solving [13], [14]. Virtual reality can be used in simulation learning methods which are basically games that are lifted from reality to help understand the nature of concepts or principles through problem solving from life [13], [15]. The characteristics of Virtual Reality technology adopt practicum learning process to increase learners' ambition and interest in experiencing real situations without using real props. Virtual Reality also minimizes damage and budget expenditures in the practicum learning process. The utilization of Virtual Reality is expected to be an activation of interaction in the learning process so that it becomes easier to use.

In the development of Virtual Reality-based learning media for simulating Optical Fiber Splicing, it will be packaged using Blender software as a medium for making objects and environments, Unity as a medium for making interactions and Oculus Quest 2 devices for Virtual devices. In addition, Virtual Reality can be a substitute media in practicum. Students will learn the use of tools during Fiber Optic Splicing by solving cases through practice. This will make it easier for students to remember the use of tools compared to seeing exposure to information from videos. Virtual Reality also minimizes the cost of using disposable materials such as fiber cables and fiber splicing tools that have high prices. Therefore, it is necessary to conduct research on the development of Virtual Reality for simulating Optical Fiber Splicing which is able to provide practicum resembling the actual situation. Therefore, it is necessary to design practicum media that can support learning Optical Fiber Splicing as a practicum tool, and qualifications so that students can perform Optical Fiber Splicing efficiently including knowledge or concepts and skills.

METHOD

The author carried out the development procedure using the development model proposed by Luther. The development model is the Multimedia Development Life Cycle (MDLC) of Arch C. Luther [16]. MDLC is a

multimedia software development model with six stages so that concrete, targeted, and effective software is formed [16]. The stages of this development model consist of Concept, Design, Collecting Content Material, Assembly, Testing, and Distribution. The stages of this development model are shown in Figure 1.

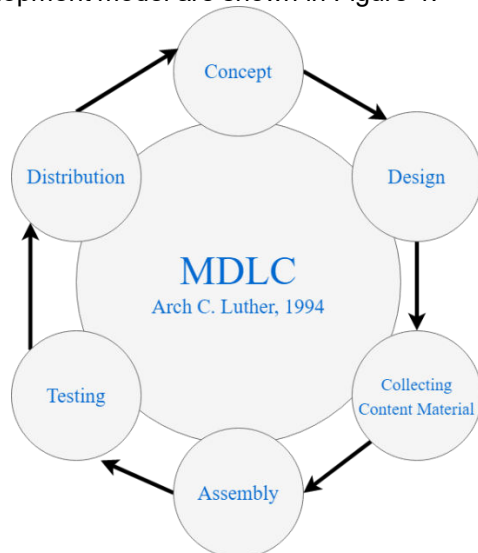


Figure 1 Luther MDLC Development Model

At the Concept stage, the author defines the purpose of software development in order to create Virtual Reality for simulating Optical Fiber Splicing so that it can be used as a learning media and a place to practice Optical Fiber Splicing. In learning related to Optical Fiber Splicing, students are still unable to implement the skills and procedural knowledge of Optical Fiber Splicing when meeting with real tools. This Virtual Reality is designed for students who take advanced computer network courses with the hope of providing learning experiences in the practice room together with tutors. This virtual reality includes 3 aspects, namely orientation, training, and simulation. In the User Orientation aspect, the tutor will teach about fiber optic networks, the functions of fiber optic networks, the disadvantages and weaknesses of fiber optics, and others. In this section, the tutor will explain the material and occasionally ask questions to the player. Users will be given information related to the tools / materials that will be used in Fiber Optic Splicing. In the Exercise aspect, the user will carry out the Fiber Optic Splicing Exercise according to the procedure accompanied by the tutor. Users will be guided to carry out the Fiber Optic Splicing Procedure. In the Simulation aspect, the user will carry out the

Optical Fiber Splicing Simulation according to the procedure independently.

The second stage defines the design of the media architecture in detail according to the media specifications. In the form of Navigation Structure or user interface and Storyboard and other needs. In this stage, an outline of the media design is made. The storyboard describes the visual sequence of the user experience. Users will be able to interact with the tutor, practice, and practice independently.

The Material collecting stage is the collection of materials that are suitable for the needs. Collection of necessary materials. All kinds of data such as images, sketches, videos, audio, animation, will be stored in digital format as a reference or initial construction material in making this learning media.

At the Assembly stage, learning media will be made according to the design design of all objects, environments, and interactions. The order of making learning media starts from creating assets, objects, and virtual world environments. Preparation of the whole into Unity so as to produce a virtual environment. Followed by the creation of movement on the user character. Then creating interaction with the tutor (animation, audio, and scheme). Furthermore, making interactions with Fiber Optic Splicing practice tools and making evaluations.

The testing phase is carried out with the Blackbox Test of process correctness & feasibility, Content Expert Test, and Media Expert Test. This stage aims to detect errors or ambiguities in the developed units so that they are immediately corrected. If all units are in accordance with the design and there are no revisions, the product can be distributed. The process correctness Blackbox test focuses on the functionality of an application. This test does not look at how the programming process in an application but rather prioritizes the input and output of the application. Therefore, this test is carried out to validate the functional part of the application, namely Main Menu State, Game State, Tutorial, and Setting. In the blackbox test of the feasibility of Virtual Reality learning media applications for Optical Fiber Splicing Simulation, carried out with the validity of experience, goals of education, and learning. The assessment by the expert test and media test will be calculated using the content validity used in the expert assessment using Gregory's formula [17]. According to Gregory, some experts can determine the coefficient of content validity. The distribution stage is the last stage

in the development of Virtual Reality for Optical Fiber Splicing Simulation. Distribution begins when the media has been declared fit for use.

RESULT AND DISCUSSION

The final result of research and development using the Multimedia Development Life Cycle (MDLC) model from Arch C. Luther is a simulation media for the practice of Optical Fiber Splicing with Virtual Reality that can be used with Oculus Quest 2. This simulation helps students understand the concepts and procedural knowledge of Optical Fiber Splicing through practice in Virtual Reality.

1. Concept Stages

At this stage, the author defines the purpose of software development in order to create Virtual Reality for the simulation of Optical Fiber Splicing in accordance with the indicators contained in the advanced computer network course syllabus so that it can be used as a learning medium and a place of practice for Optical Fiber Splicing. In the results of the conceptualization stage, the technology used is Virtual Reality Development using the unity application, the C# programming language, and the Oculus Quest 2 device. The purpose of developing this software is to be able to

create Virtual Reality for Optical Fiber Splicing simulations to be used as a place of practice / simulation before students implement it in real life. The application scenario is taken from simulation learning, namely orientation, practice, and simulation. The output of this research and development is the Virtual Reality application for Optical Fiber Splicing Simulation.

2. Design Stages

The final result of research and development using the Multimedia Development Life Cycle (MDLC) model from Arch C. Luther is a simulation. At this stage, the media architecture design is detailed in Figure 2.

At this Design stage defines the design of the media architecture in detail according to media specifications. In the form of Navigation Structure or user interface and Storyboard and other needs. The design results are divided into 3 sessions, namely orientation sessions, training sessions, and simulation sessions. In the orientation session using educators and information panels to guide users in digesting information about the definition, function, weaknesses, advantages, types of optical fiber and the definition and function of optical fiber work tools.

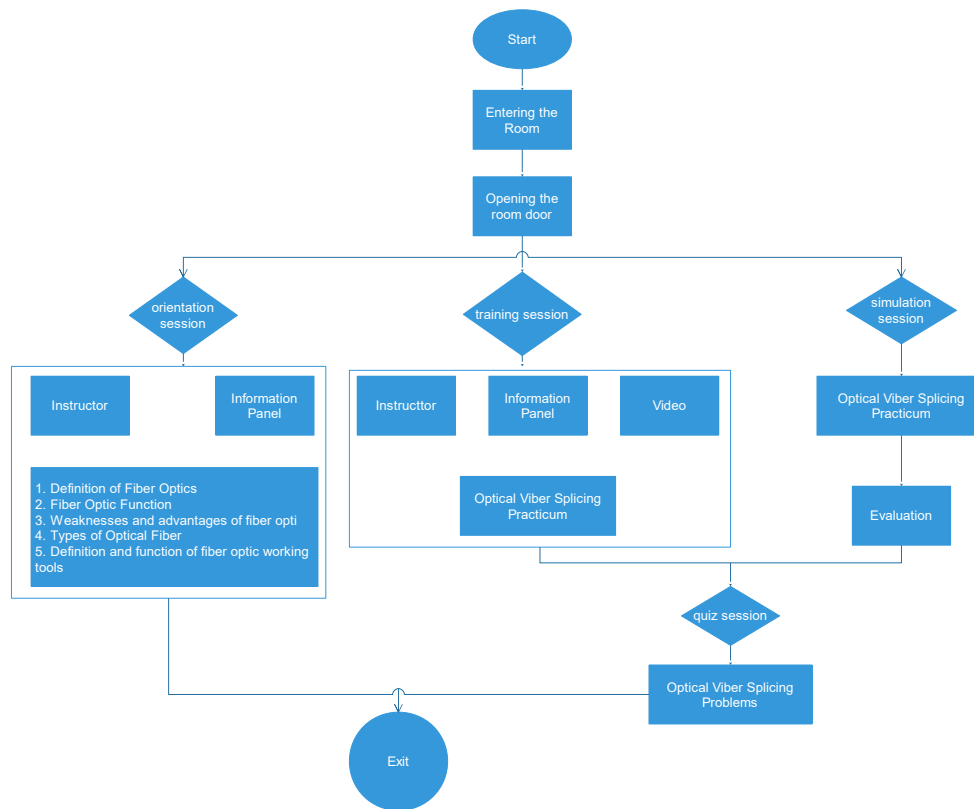


Figure 2. Application Design Results



Figure 3. Session selection area on the main menu

The training session uses educators, information panels, and videos to guide users in performing Optical Fiber Splicing Practices with the Hand Tracking function on Oculus Quest 2. In Figure 3. is a display of the selection rea for switching sessions. The sessions are sorted from right to left, namely,

orientation session, training session, and simulation session. Users are expected to receive suggestions from Non Playable Character (NPC) to enter the session in order.

In the simulation session, users practice independently and the results will be evaluated. As for other needs in the form of 3D

object design, here is one of the 3D object designs. Figure 4 presents a view of the auto fusion splicer used in splicing optical fibers. This fusion splicer has a fairly high level of accuracy for perfect splicing. Figure 5 presents the design view Stripper or miller is a medium that functions to cut and peel the skin & cable meat. Figure 6 presents a view of the

computer laboratory, which is the laboratory that will be used in oculus quest 2. The design used is very simple and provides visualization with low latency. With this laboratory, users will not experience lag and/or Fps drop so that users can focus on practicing Optical Fiber Splicing

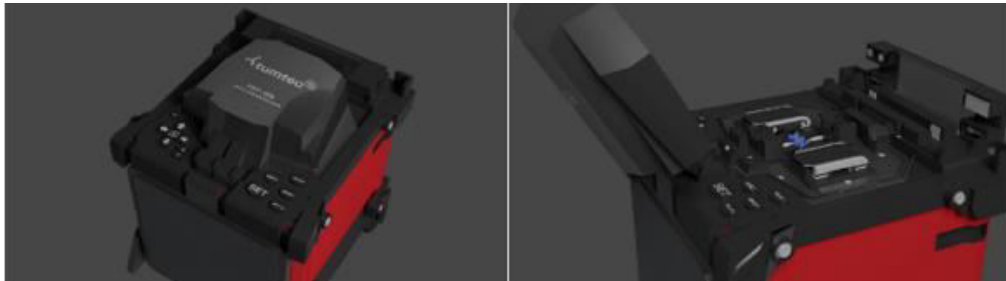


Figure 4. Design 3D Auto Fusion Splicer

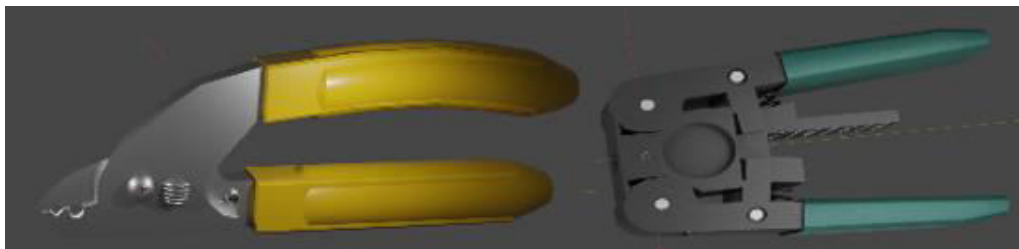


Figure 5. Design Miller & Stripper

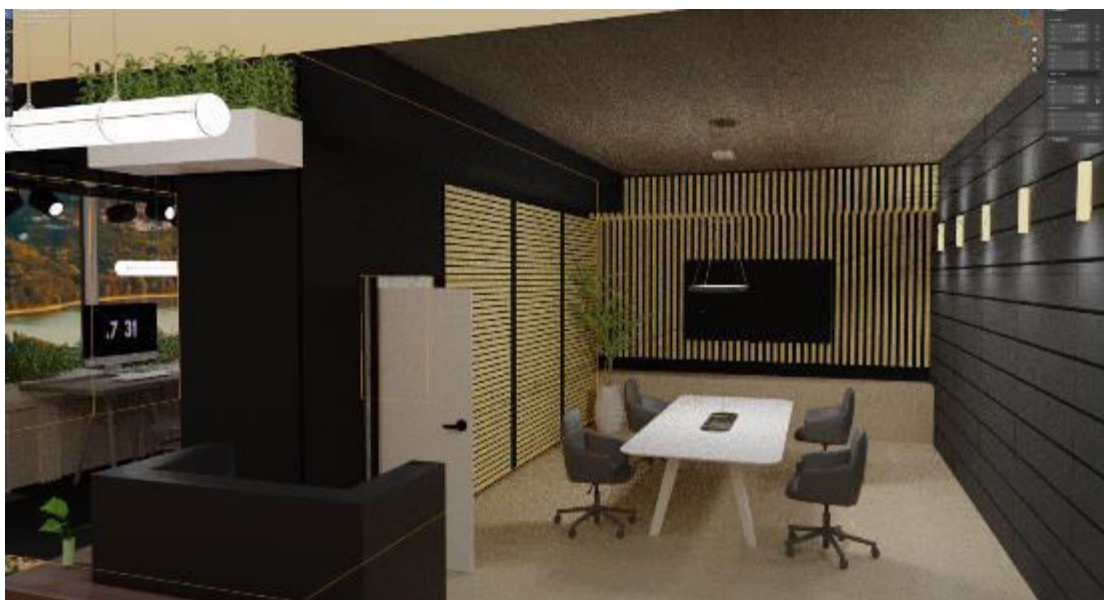


Figure 6. Computer Laboratory

3. Material Collecting Stage

The Material Collecting stage is the collection of materials that are in accordance with the needs. All kinds of data such as images, sketches, videos, audio, animation, will be stored in digital format as a reference or

initial construction material in making this learning media. At this stage the collected materials are sorted out to be used in the menu, orientation, exercises, simulations, and quizzes.

4. Assembly Stage

At the Assembly stage, learning media will be made according to the design of all objects, environments, and interactions. The arrangement of making this media is as follows. At the stage of creating assets, objects, and virtual world environments, the process of creating 3D objects related to

practicum tools to the room is carried out using the Blender application. After the 3D object is successfully created, it is exported into FBX format so that it can enter the Unity application. Compilation of the whole into Unity so as to produce a virtual environment. Figure 7. Showing the practicum area.



Figure 7. Showing the practicum area

Each 3D object in FBX format is imported into Unity. Before the objects are arranged in the Unity scene, the developer extracts textures and extracts materials. In this scene, each object is resized to fit the OVRCameraRig and OVRInteraction. Addition and adjustment of post-processing and lighting to beautify the area. In the user character, several interactions and adjustments to OVRInteraction are added, namely locomotion, and hand interactable. Locomotion uses hand poses and changes poses in movement. Users can also move in Virtual Reality by walking in the real world according to the boundaries that have been set. Figure 8. is a view of User locomotion. In the teaching object shown in Figure 9, the developer added rigs to the head and equipped the head with a tongue and teeth using the Blender application. The developer combines the body rig and head rig into one unit. Then the

developer creates a Lipsync educator. After that, the tutor object is imported into the Unity application and a timeline is formed containing a series of tutor movements that have been made. In making interactions with the Fiber Optic Splicing practice tool shown in Figure 10, the developer assembles the Fiber Optic Splicing practice scheme from start to finish and makes all the hand interactions needed for each object. Developers create various conditions in practice and provide error management in Optical Fiber Splicing such as errors not clamping the stripper when cutting the cable coating and taking cables that have been connected using 2 hands.

The developer created an evaluation on the simulation section shown in Figure 11. At the end of the simulation session, the user will be given a score related to what has been simulated and given a description of what the user has not done.



Figure 8. User locomotion

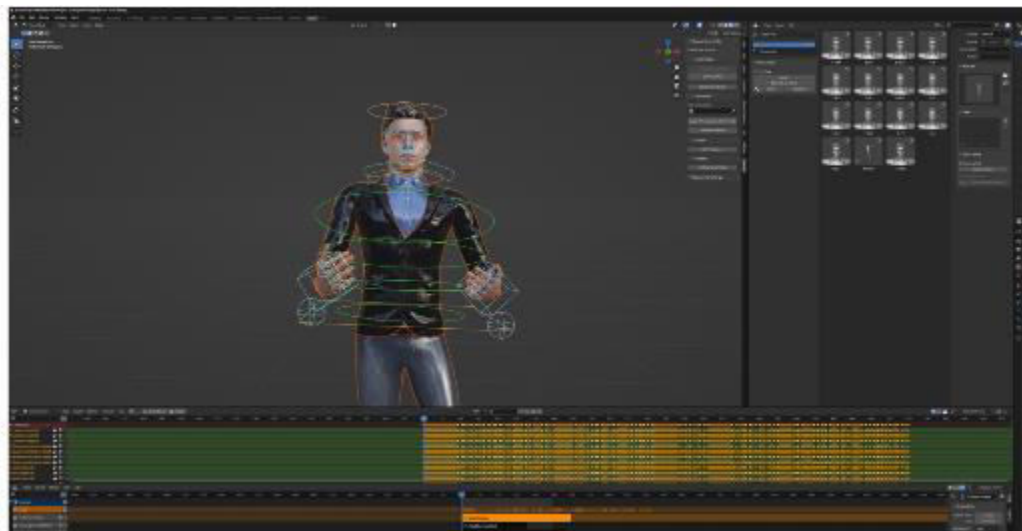


Figure 9. Tutor Interaction Creation

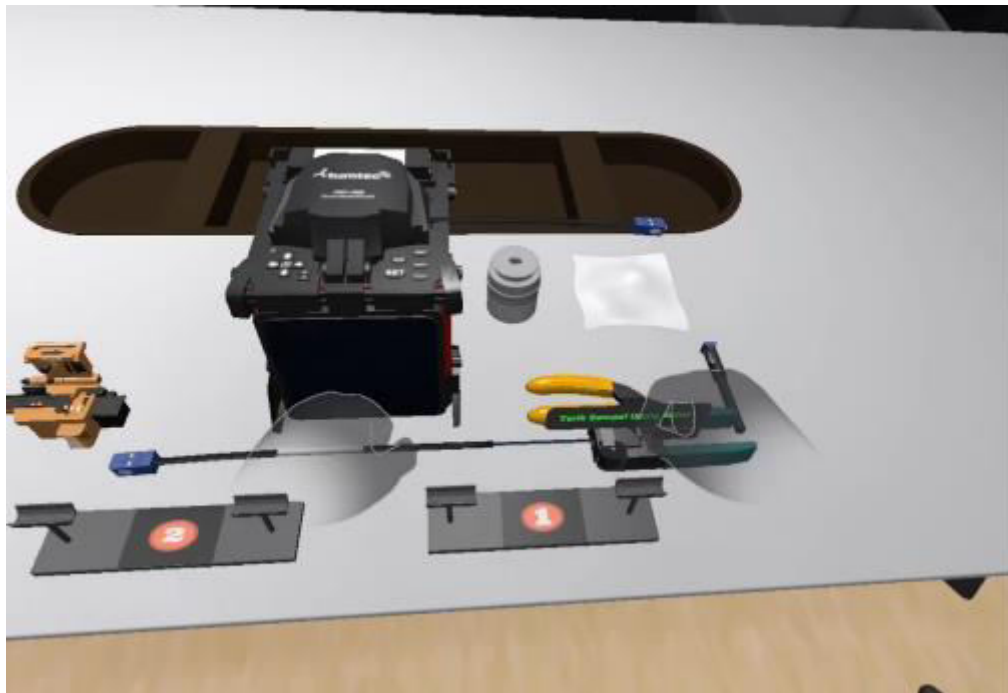


Figure 10. Use of Work Tools



Figure 11. Simulation Evaluation View

5. Testing Stage

The testing phase is carried out with the Blackbox Test of process correctness & feasibility, Content Expert Test, and Media Expert Test. This stage aims to detect errors or ambiguities in the developed units so that they are immediately corrected. If all units are in accordance with the design and there are no revisions, the product can be distributed. Blackbox testing is divided into 2 namely, process correctness, and feasibility. Process correctness testing focuses on the functionality of an application. This test does not look at how the programming process in an application but rather prioritizes application input and output. In the process correctness blackbox test, there are

4 functional application tests. In the Main Menu State application functional, with the input of selecting the door to enter the session, the user can be moved to the selected session. In the functional Game State application, the session selected in the Main Menu State can run according to the purpose of the session until the end. In the How to Play application functional, the user can be provided with information related to the use of the hand through a dynamic interface located on the wrist of the hand while in the Main Menu State and several information Display Panels. In the Exit application functional, the application can be

closed completely. The results of the process correctness blackbox test in table 1.

In testing the feasibility of Virtual Reality learning media applications for Optical Fiber Splicing Simulations, carried out with the validity of experience, goals of education, and learning. This test is dedicated to forming suitability in the formation of applications with learning objectives. In the application feasibility blackbox test, there are 3 test indicators. In the Experience indicator, the use of Virtual Reality provides an Immersive sensation in a virtual environment and in the practice of Optical Fiber Splicing. In the usage experience, initial information is needed for users related to hand tracking such as, how to move places, and how to use work tools so as not to be confused in the middle of use. In the Goal of Education indicator, the information/data is in accordance with the RPS Advanced Computer Network in the Fiber Optic section by embedding information, sessions, practices, related to fiber optic networks, fiber optic functions, fiber optic weaknesses, fiber optic advantages, Fiber Optic Splicing problems, Fiber Optic Splicing work tools, and Fiber Optic Splicing procedures. In the Learning indicator, the application is designed to provide information and practice space for Optical Fiber Splicing so that users can perform Optical Fiber Splicing. The results of the feasibility blackbox test in Table 2.

The next testing stage is the content expert test and media expert test. Content expert testing in Virtual Reality for Optical Fiber Splicing Simulation is carried out by two

academic experts (P1 & P2) in the network field, namely teachers from the Informatics Engineering Study Program, Ganesha University of Education. In the assessment of the content expert test on Virtual Reality for Optical Fiber Splicing Simulation, the validity coefficient is 1.00 with very high qualifications, and the criteria are very valid. This means that the content in the application is appropriate / valid. However, there are several things that still need to be improved, namely, sensitivity, and boundaries. The sensitivity of using the tool is very high, hence the need for mechanism information in order to use the tool properly. Boundaries are needed when users move places and cut cables. Therefore, the author creates an information panel related to cable cutting and enlarges the object collider so that it can be more easily taken. When the user rotates the tool lid, prior knowledge is required because the hand is still detected holding the tool lid even though the hand is far away from the tool lid due to the sensitivity of the device. The user must open the hand completely so that it is not detected as still holding the lid. Users must know the indicators used in holding the tool and using the tool. Despite knowing the indicators, sometimes users still make mistakes in performing the clamped and unclamped poses in using the miller and stripper. This is often due to misconceptions in virtual reality. The content expert test uses the Gregory validity test. The results of the content expert validity test are shown in Table 3,

Table 1. Results of Blackbox Testing for Process Correctness

Indicator	Result
Main Menu State	Runs well, can take the user to another state
Game State	Runs well, each session goes according to the goal until the end of the session
How to Play	Runs well, can provide information about hand usage
Exit	Runs well, the application can be closed perfectly

Table 2. Application Feasibility Blackbox Test Results

Indicator	Result
Experience	Immersive, unique and interesting when using the application, but requires initial information regarding hand tracking.
Goal of Education	Information/data in accordance with Advanced Computer Network RPS for the Fiber Optic section.
Learning	The information / data provided related to the understanding of the Fiber Optic Splicing Procedure is formed in orientation sessions, exercises and simulations

Table 3. Content Expert Assessment Cross Tabulation

		P1	
		Less Relevant	Very Relevant
P2	Less Relevant	0 (A)	0 (B)
	Very Relevant	0 (C)	20 (D)
Validity Coefficient		1.00	

Table 4. Media Expert Assessment Cross Tabulation

		P1	
		Less Relevant	Very Relevant
P2	Less Relevant	0 (A)	0 (B)
	Very Relevant	0 (C)	20 (D)
Validity Coefficient		1.00	

Furthermore, media expert testing in Virtual Reality for Optical Fiber Splicing Simulation is carried out by two academic experts (P1 & P2) in the field of media, namely teachers from the Informatics Engineering Study Program, Ganesha University of Education. The media expert test uses the Gregory validity test. In the assessment of the media expert test on Virtual Reality for Optical Fiber Splicing Simulation, the validity coefficient is 1.00 with very high qualifications, and the criteria are very valid. This means that the media in the application is appropriate / valid. The thing that needs to be considered is the display of applications in Virtual Reality on large images that are compressed into small ones giving the appearance of lines on the edges and blur when at a distance from the headset. Therefore, the author enlarges some parts of the object except the Optical Fiber Splicing work tool which is still suitable or close to its real size. The results of the media expert validity test are shown in Table 4

6. Distribution

The distribution stage is the last stage in the development of Virtual Reality for Optical Fiber Splicing Simulation. Distribution begins when the media has been declared fit for use. This distribution is carried out in the installation into the Oculus Quest 2 in the Informatics Engineering Study Program of Ganesha University of Education and the distribution of applications in Open Source. This application can be used by anyone using the Oculus Quest 2 device to run properly. In detail, 4 sessions in Virtual Reality for Optical Fiber Splicing Simulation have been embedded in the application.

The development of Virtual Reality for Optical Fiber Splicing Simulation applies the Hand Tracking function to Virtual Reality and

can be used anytime with the Oculus Quest 2 device. Development is done by applying Virtual Reality technology with Hand Tracking function and using 3D objects that resemble optical fiber work tools. The development process is based on immersion that allows users to feel the sensation of the virtual world mentally and physically, the Virtual World that is made to resemble a 3D environment with Optical Fiber Splicing work tools, feedback to the user's senses, interactivity, so that users can feel the practice of Optical Fiber Splicing that takes the characteristics of real life [18]. The existence of this learning media application provides students with a place to practice Optical Fiber Splicing so that the error rate will be lower when students will apply Optical Fiber Splicing techniques with real tools.

The Optical Fiber Splicing procedure is in accordance with the practice of Optical Fiber Splicing in Virtual Reality. The Optical Fiber Splicing procedure that the author embeds in Virtual Reality is in the form of Optical Fiber Splicing and testing with a Fault Locator. As for one of the references used from SKKNI 2018 Unit code J.611FO00.014.2 with the unit title carrying out Optical Fiber splicing with Fusion Splicer [19]. The language and presentation are appropriate and work well. However, there are some things that still need to be improved, namely, sensitivity, and boundaries. The sensitivity of using the tool is very high, so mechanism information is needed in order to use the tool properly. Boundaries are needed when users move places and cut cables.

The results of the development of Virtual Reality for Optical Fiber Splicing Simulation provide an immersive sense for users. A sense of presence in an ecosystem or virtual environment and interact directly with hands using Hand Tracking. The stimulation and

attraction provided to users in understanding and carrying out the practice of Optical Fiber Splicing in a virtual environment increases the interest in using Virtual Reality. In Virtual Reality for Optical Fiber Splicing Simulation, based on the results of expert testing, it is very much felt that Learners-centric learning, especially in the process of acquiring knowledge and skills of Optical Fiber Splicing through hands-on practice. The usage experience in the familiarization phase of using the Hand Tracking feature does seem new, exciting, and challenging. When users are accustomed to using Hand Tracking, learning in Virtual Reality is faster to execute compared to the first time using the application.

Based on the entire testing phase ranging from blackbox tests, content expert validity tests, and media expert validity tests, indicating that the development that has been carried out is successful and feasible to use. This application can be used as a learning media, acts as a teaching aid before entering the real practicum, and minimizes the cost of damage to teaching aids.

CONCLUSION

The results of the design and implementation of Virtual Reality development for Optical Fiber Splicing Simulation using the Multimedia Development Life Cycle (MDLC) development method with 6 stages. The stages of this development model consist of Concept, Design, Collecting Content Material, Assembly, Testing, and Distribution. The testing stage is carried out through 3 tests, namely, Blackbox test, media expert test, and content expert test, and user experience test / field test. The Virtual Reality development process for Optical Fiber Splicing Simulation uses Blender as a 3D object creation and Unity as a Virtual Reality application creation. In the process of making this application, the application is dedicated as a place to practice Optical Fiber Splicing in a 3D virtual environment with all interactions using Hand Tracking. The output of this application can be run on a Virtual Reality device, namely Oculus Quest 2. Further research will be carried out in the user experience test process using the User Experience Questionnaire (UEQ) data analysis instrument..

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