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Development of Fiber Optic Practicum Learning Media based on Virtual Reality with Interactive 3D Animation

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***Abstract*—The rapid development of multimedia technology has encouraged innovation in learning media, particularly for practical-based courses. Fiber optic practicum learning requires direct practice, specialized equipment, and adequate laboratory facilities, which often become constraints, especially during distance learning. This final project aims to develop a virtual reality–based learning media for fiber optic practicum to support students' understanding of practicum procedures in an interactive and immersive manner. This study employs a system design and development method consisting of analysis, design, implementation, and testing stages. Blender is used for 3D modeling and animation to design laboratory environments and fiber optic practicum equipment, including stripper, cleaver, fusion splicer, optical power meter, and fiber optic cables. Verge3D is utilized to create interactive animations and integrate the models into a virtual reality environment. The developed learning media simulates key practicum stages such as cable stripping, cutting, splicing, and attenuation measurement. Testing results show that the developed learning media operates properly with a functional success rate of 100%. User evaluation results indicate an average usability score of 85%, demonstrating good performance and usability. These results indicate that the proposed learning media is effective in improving students' understanding and readiness before conducting actual fiber optic practicum in the laboratory.**

Keywords—virtual reality, learning media, fiber optic practicum, Blender 3D

I. INTRODUCTION

In today's technological era, the role of multimedia plays a very important role in the development of science and technology. These developments are not only in the field of industry and business but can also play a role in the field of education. One of the benefits of multimedia is as a tool in learning media. With multimedia, learning media can be made more interesting and provide examples in visualization.

Practicum or experimental courses are an important learning method to be implemented in learning because they can provide direct experience to students to introduce, familiarize, and train students to carry out scientific steps and procedural knowledge [1]

With the advancement of technology, practicum activities can be complemented by virtual practicum-based learning. Virtual practicum can be used as an alternative to focus students' or students' attention on teaching and learning activities and to practice conducting real practicums. Practicum activities can be practiced using the virtual world [2]

In the Covid-19 conditions, students have difficulties in conducting practicum learning online. Various *platforms* are used to carry out the online learning process so that it needs to be supported by good facilities and the use of information technology. One of the latest innovations to get information today is *Virtual Reality (VR). Virtual Reality* is a technology that allows a person to simulate an object using a computer that is able to evoke a three-dimensional atmosphere so that the user seems to be physically involved. Virtual Reality *technology* has made a huge difference in the history of human thought and is currently trending to help improve the quality of performance and products [3] [4]

One of the media that can facilitate VR is animation. Animation is an image that moves at a certain speed, direction and manner in which there is a process of recording and replaying a series of static images to obtain the illusion of movement. In making animations, an animation software is needed to make them. Blender is an animation software that is a 3D graphics software used to create animated films, visual effects, 3D printed models, interactive 3D applications, and video games. The software can also be used on multiple operating systems, such as Windows, *macOS,* and *Linux*. In fact, there are many 3D animation software that can be used, but Blender is still the best 3D animation software. This is because Blender provides a variety of interesting features for its users**.**

The process of creating learning media in the form of animation using *software* Blender 3D fusion *Fusion Splicer or* fiber optic *splicing* is required, which is the process of *fiber optic splicing*, such as *a core patch* and for the *fiber optic splicing* process it is carried out by *cutting fiber optic* using *a cleaver* or cutting and stripping *fiber optic* cable using *a stripper* or cable stripper *fiber optic*. The next process to find out the results of the connection of *fiber optic* cables is using *the Optical Power Meter* (OPM) tool. With this tool, you can determine the signal strength of *the fiber optic cable* that supports the functioning of *the 3D blender* software.

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Research by Soni Ariatama et al. (2021) shows that the use of smartphone-based Virtual Reality (VR) technology with gyroscope and accelerometer sensors is able to increase learning interest, but the developed system still uses 2D VR so that the immersion level is not optimal [5]. Furthermore, the research Hari Antoni Musri et al. (2020) has leveraged VR with 3D objects using Blender, but has not yet provided interactive assembly simulations as a means of learning evaluation[6].Research Lestari et al. (2025) develop VR learning media that is visual and interactive and proven to improve user understanding, but the simulations developed are still limited to certain visualizations and do not fully represent technical practicum that is procedural and measurement-based [7]. Based on these limitations, this study presents a novelty in the form of the development of Virtual Reality-based Fiber Optic practicum learning media that simulates all stages of practicum systematically, starting from cable cutting, splicing, to measuring results using Optical Power Meter (OPM), so as to produce learning media that is more immersive, interactive, and close to real laboratory conditions.

II. METHODS

This research uses the Research and Development (R&D) method chosen because it aims not only to produce products in the form of learning media, but also to systematically design, develop, and test Virtual Reality-based Fiber Optic practicum learning media. The research design includes the stages of needs analysis, system design, development, implementation, and testing. The system architecture was designed by utilizing Blender as a 3D object modeling and animation software for fiber optic practicum equipment, which was then integrated using Verge3D to build the interaction and flow of the practicum simulation in a Virtual Reality environment. The selection of Blender and Verge3D was based on their ability to produce realistic 3D visualizations and support VR-based interactive integration. The media developed simulates the stages of the practicum in sequence, starting from cable cutting, splicing, to damping measurements using an Optical Power Meter (OPM). The testing scheme is carried out through functional testing to ensure that all system features run properly, as well as usability testing to assess ease of use and user comfort. The evaluation metrics used include the percentage of success of the system function and the usability value in the form of percentages, which are used to determine the feasibility and performance of the developed learning media.

This research applies research and development methods to develop Virtual Reality-based learning media for fiber optic practicum. This methodology focuses on the design, development, and implementation of an interactive virtual laboratory that simulates fiber optic practicum procedures. The research stages are carried out systematically to ensure that the learning media developed functions properly and meets educational objectives.

A. System Diagram Blocks

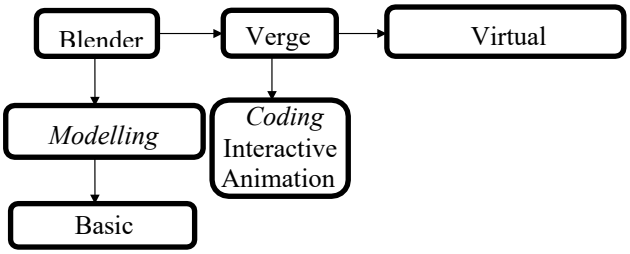

Figure 1. System Planning Diagram Block

Based on the block diagram in figure 3.1, blender has a role as software to make 3D object modeling in the *Fiber Optic* Practicum learning. After the modeling is complete, basic animations are made on 3D objects that have been designed to look more real. The animation coding process is continued through Verge 3D software. Next, it is exported to virtual reality so that the modeling and coding that has been made can be seen by students and students as if it seems real using *virtual reality* shaped like convex glasses.

B. Flowchart Process

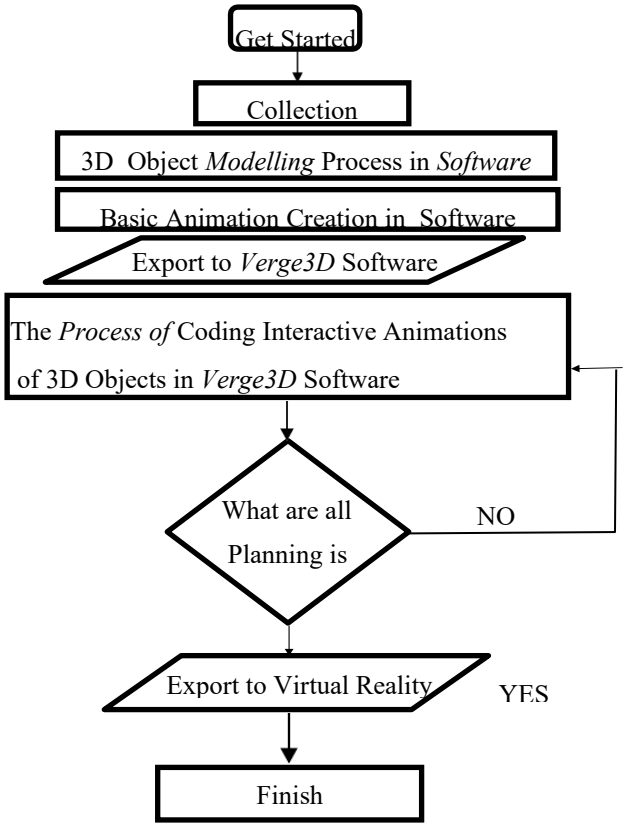

Figure 2. *Flowchart* 3D Animation Design Process

The process of making animations in Virtual *Reality-based Fiber Optic* learning begins by taking data or objects that will be used in the design. Where the data is in the form of learning modules in accordance with the curriculum used by the institution, the materials taken are also more focused on *learning stripper*, *cleaver*, *splicer,*

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and OPM measurement. After the data is received, a modeling process is carried out using blender software based on the data that has been taken. In addition to the process of making objects, the blender application also makes basic animations. Then, the 3D modelling is exported to the Verge 3D software for an interactive animation coding process. After the modeling and coding process is completed, the next process is to export to VR glasses. The following is a picture of the system flowchart which is the flow of the process of working the system until the process is completed.

C. Blender Software Design

Before starting the design or modeling process, an object needs a blender software to work. One of the main objects that plays a role in this blender software is to use basic objects such as *cubes, cylinders, planes* and others.

There are many *shortcuts* available in this *software*, which aims to make it easier to model an object. The following is the process of installing blender software as follows**:**

1. Download the blender software for free https://www.blender.org/download/.

Figure 3. Blender Download View

2. When the file is finished downloading, open the file to start the installation.

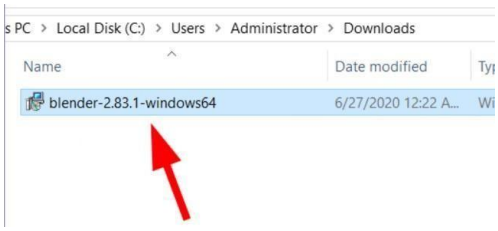

Figure 4 Finished Blender File View Download

3. Click the Next button.

Figure 5 Initial View to Install the Blender After the blender file

4. installed and 'License Agreement' appears. Click the 'I Accept' button and then click the Next button

Figure 6 Program Installation Opening Display

5. Select the location of the blender software installation. By default it will be redirected to directory C. Click Next.

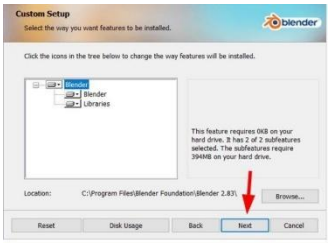

Figure 7 Blender File Location View Click the install button

6. 

Figure 8 Ready to Install Blender Display

7. This view shows the process *of installing* the program that lasts some time.

Figure 9 Program installation process view

8. If the installation process has been completed, the following display will appear.

Figure 10 Display after successful installation of the program

9. In this view, the blender software is installed and can be used.

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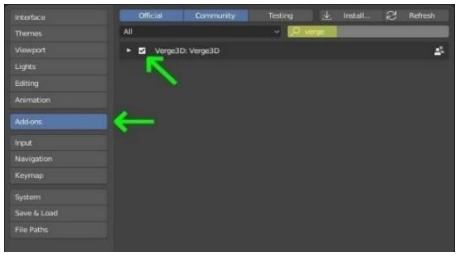

Figure 11 Initial view of the blender software

D. Verge 3D Software Installation

1. Download the installer file on the official website of the Verge 3D software, which is https://www.soft8soft.com/get-verge3d/. After successfully downloading the installer file, double click the file to start the installation process.

Figure 12 Download Verge 3D for Blender

2. Double-click on the exe file to run the installation process.

Figure 13 Verge 3D Installation Initial View

3. Select the installation folder or better left it by default.

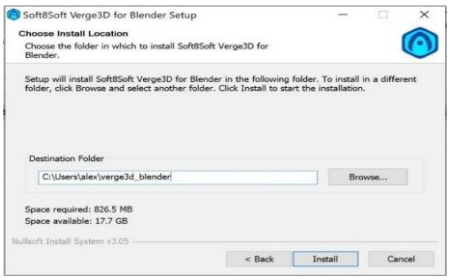

Figure 14 Folder Location Selection View

4. Once the installation process is complete, open the blender app. If you want to run it, make sure to close it and open it again. Open the preferences window. Then, find and activate the Verge 3D Add-Ons, then click Save Preferences and close the window

Figure 15 Verge 3D Add-Ons Display in Blender

E. Shortcut Blender 3.0

A shortcut (short for command) is an advantage of windows that allows us to place an icon anywhere on windows, even on the desktop, so that by clicking on it we can open a file or program. A shortcut is a feature provided by a computer to the user to provide a quick way to reduce the processes or steps in a task. If interpreted in language, namely short (English) then it means short and cut (English) means to cut. In principle, a shortcut can be said to be cutting a long path or a long way to produce a short way [8]

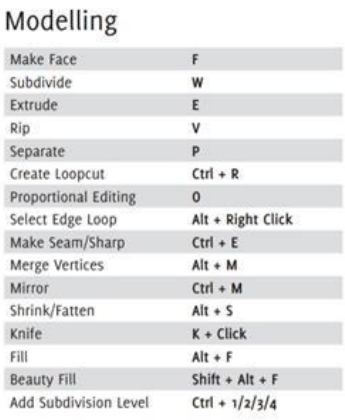

Figure 16 Shortcut Modelling Blender

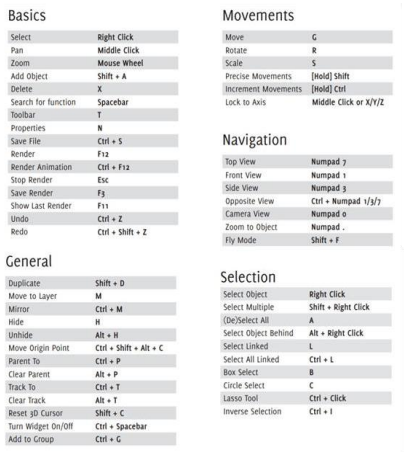

Figure 17 Shortcut Blender

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F. Planning *Modelling* Object Laboratory Room

The creation of space objects in the Telecommunication Laboratory uses basic objects such as cubes, cylinders, planes and others. The object to be designed is as at

Table 1 Laboratory Room Objects

No	Object Name	Quantity
1	Stripper	2
2	Cleaver	1
3	Splicer	1
4	Router	1
5	OPM	1
6	Fiber Optic	1

The following is a view of the modelling design in the Laboratory room.

1. Laboratory Table Modelling

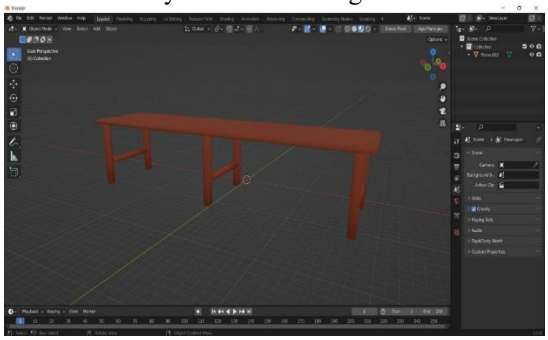

Figure 18 Modelling Laboratory Table

2. Modelling Chair

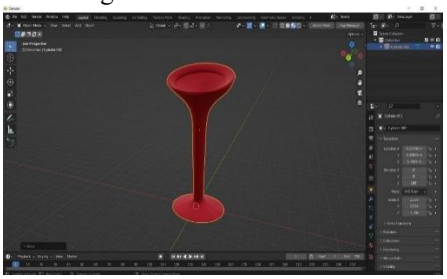

Figure 19 Chair Modelling

3. Modelling AC

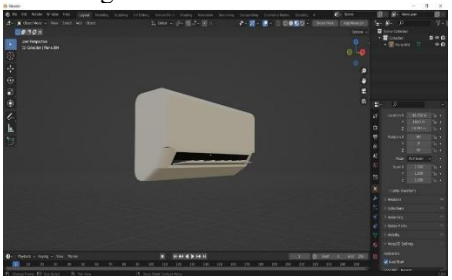

Figure 20 AC Modelling

4. Modelling Room

Figure 21 Room Modelling

G. Fiber Optic Practicum Practicum Learning Material Modelling Design

The objects to be designed are as follows.

Table 2 Fiber Optic Practicum Learning Objects

No.	Object Name	Quantity
1.	Table	2
2.	Seats	4
3.	AC	1
4.	room	1

The following is a view of modelling design in Mathematics learning

1. Modelling Stripper

Figure 23 Modelling Stripper

2. Modelling Cleaver

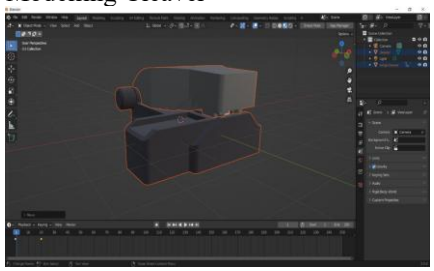

Figure 24 Modelling Cleaver

3. Modelling Splicer

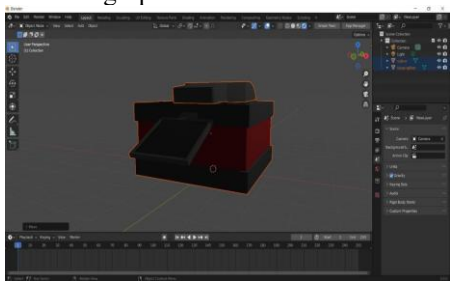

Figure 25 Modelling Splicer

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4. Modelling Router

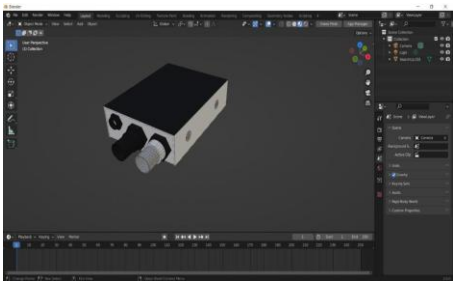

Figure 26 Modelling Router

5. Optical Power Meter

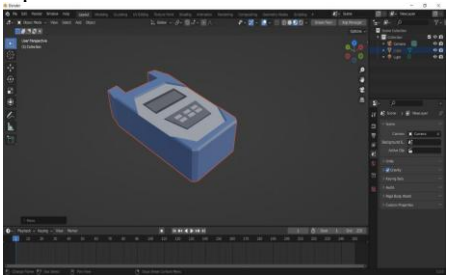

Figure 27 Medelling Optical Power Meter

6. Modelling Fiber Optic

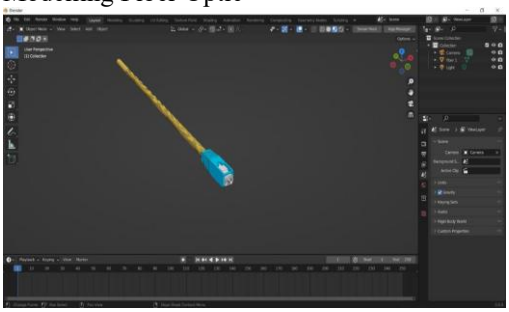

Figure 28 Modelling Fiber Optic

H. Animation Design

NO	Skenario	Deskripsi
1	Running Virtual Reality mode	It is the process of running the VR mode by clicking on the available VR mode.
2	Running Step 1	It is a process to cut and peel Fiber Optic skin 1 using a Stripper
3	Running Step 2	It is a process to cut and peel the skin of Fiber Optic 2 using a Stripper
4	Running Step 3	It is a process to cut the *Fiber Optic* cable that has been cut and peeled using *a cleaver,* then immediately insert *the Protection sleave*
5	Running Step 4	It is a process of connecting the two Fiber Optic cables using a splicer, then the protection sleave that has been inserted is shifted until it closes the Fiber Optic fiber
6	Running Step 5	It is a process to measure Fiber Optic cables using OPM

I. Working Principle

The way this Virtual Reality *works* will make it seem as if students are doing a Fiber Optic simulation practicum using Stripper, Cleaver splicing fiber optic and OPM calculation results at the Multimedia Engineering Laboratory of the Sriwijaya State Polytechnic. In addition to displaying visualizations of the Fiber Optic practicum using Stripper, Cleaver, fiber optic splicing and OPM calculation results, the 3D animation video is also equipped with sound (Audio) in the form of an explanation of the Fiber Optic Practicum learning material.

After the 3D object is created, the user needs an additional device, namely VR glasses that function to help the user to enter and interact directly in the 3D world. When using the VR glasses, first enter the https://v3d.net/a1e link in the browser. Then, we go straight into the laboratory room which contains a Fiber Optic Practicum Simulation which can be watched directly using VR glasses. Learning media is used as a learning guide for students and students, so that it can help the learning process at school and on campus online.

III. RESULT AND DISCUSSION

A. Main Design Results

In designing the Fiber Optic practicum Learning animation, the author uses Blender software to create room objects and learning objects. The steps to design or make animations are to do modeling design in the Blender software. This modeling design is done on a per-object basis, such as designing table objects, chairs, air conditioners, strippers, cleaver, splicers etc. For each object that has been designed, then texturing and materials are carried out. Then, combine all modeling designs such as tables, chairs, and others to form a room with an "append" feature on the blender. This is followed by the interactive animation coding process through Verge 3D software to compile the programming. Then export to virtual reality so that modelling and coding can be seen as if they were real using virtual reality tools.

This animation can be accessed through a laptop or pc and VR Box glasses. The main design of the Fiber Optic practicum learning animation is a laboratory room.

The main design of the Fiber Optic practicum learning animation. The main display of this animation is the front view of the center of the laboratory room. The image below is the result of the design of the laboratory room display. When in the laboratory room

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there are several laboratory objects such as tables, chairs, whiteboards and other objects

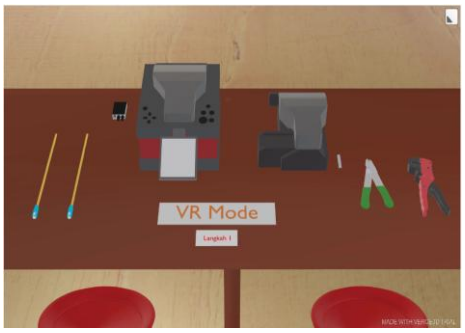

Figure 28 Main Design Results in the Laboratory Class

After entering the laboratory room, there are table objects and *Fiber Optic simulation equipment*.

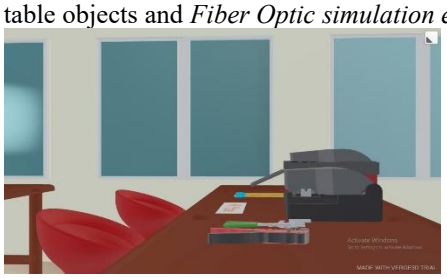

Figure 29 Main Design Result Side view left of the laboratory

Seen from the left side, there is also a window object.

Figure 30 Main Design Results Right side view of laboratory

When looking to the right of the laboratory room, there is an upper window object and a door.

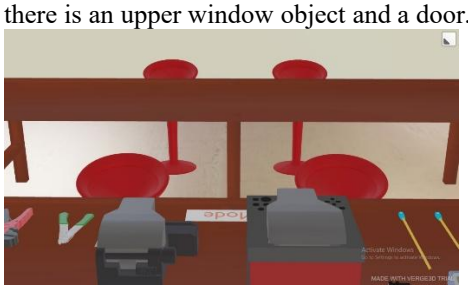

Figure 31 Main Design Results Laboratory Rear View

When looking at the back of the laboratory room, it was seen that there were objects of chairs and laboratory tables.

B. Animated Puzzles and Software Design Results

Animated Puzzles and Pembe Software Design Results lajaran Internship Fiber Optic

1. Step 1 Fiber Optic

   In the image displayed, logic to display the Fiber Optic practicum simulation object. When the step 1 command is clicked, the practicum will begin. Then select the Fiber optic cable 1, then the Stripper will move to cut and peel the Fiber Optic 1 cable, then click the Fiber Optic 2 cable, then the Stripper will move to cut and peel the Fiber Optic 2 cable.

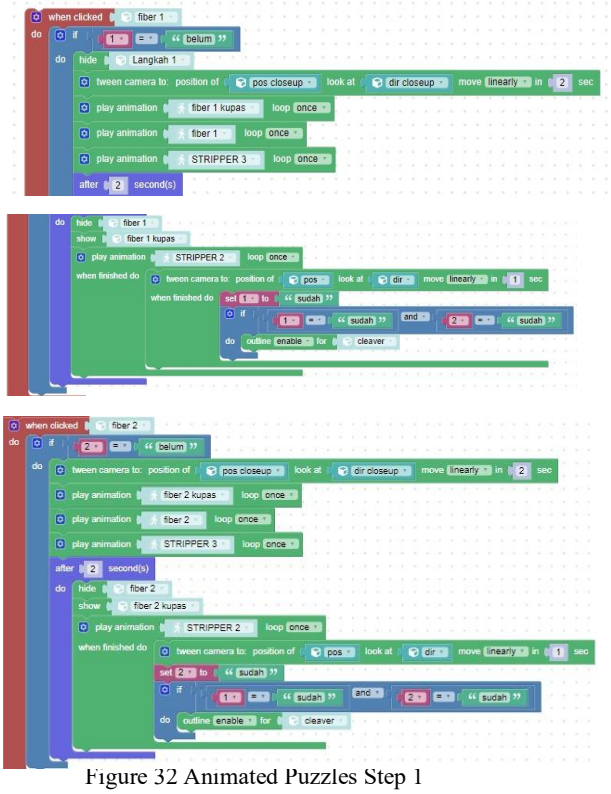

Figure 32 Animated Puzzles Step 1

2. Step 2 Fiber Optic

   In the display image step 2 results in *the Fiber Optic* cable has been peeled off. Then click *Cleaver*, then *Cleaver* will move to open to insert Fiber Optic cables one by one, then immediately close to cut the *Fiber Optic* fibers.

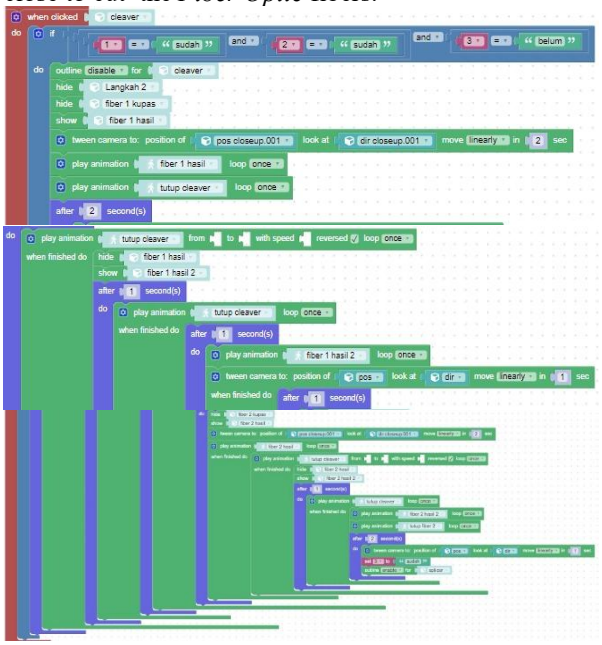

Figure 33 Animated Puzzles Step 2

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3. Step 3 Fiber Optic

In the image of display 3 produces a fiber optic cable that has been cut. Then click the splicer, then the splicer will move open to insert the two Fiber Optic cables, then directly close to connect the fiber Optic cable into one. After the fiber optic cable is connected, close the connection using Protection Sleave to protect the fiber.

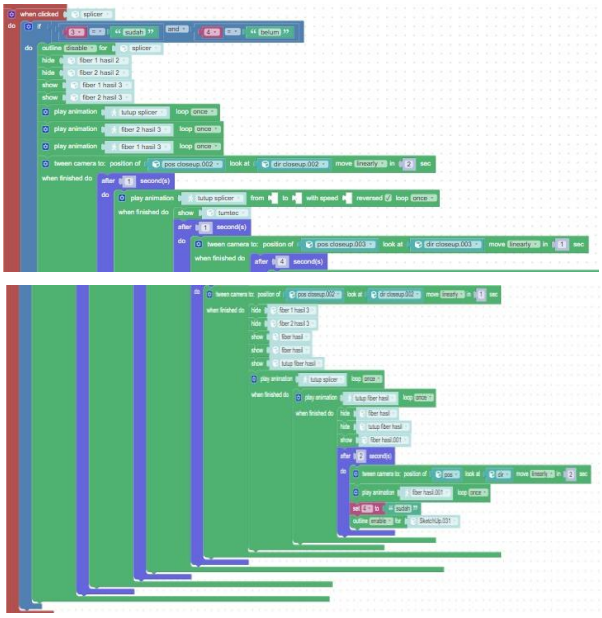

Figure 34 Animated Puzzles Step 3

4. Step 4 Fiber Optic

In the image of display 4 it produces *a Fiber Optic* cable that has been cut, peeled, connected and covered by *Protection Sleave*. Next, click *Router Board*, it will move to pair patch *core* 1 to *the Router Board*, then click *OPM*, then *OPM* will move to pair patch *core* 2, in order to measure the voltage in the *Fiber Optic* cable, if the voltage is close to 0 then the *Fiber Optic* cable It is said to be good and if the voltage is very far from the number 0 then *the Fiber Optic* cable is said to be bad.

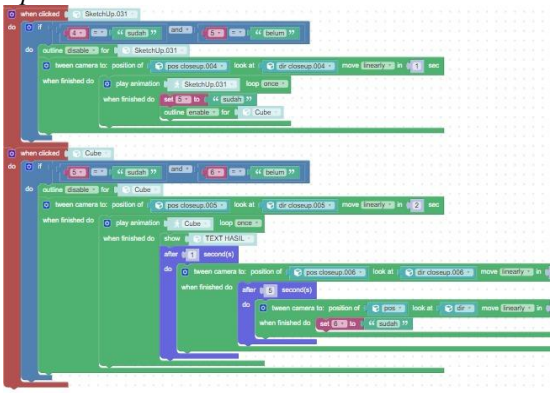

Figure 35 Animated Puzzles Step 4

C. Analyst

In making this animation, there is a Fiber Optic Practicum learning. For the design of object modeling of each of the learning materials. The objects used are the same.

The creation of objects in the Fiber Optic Practicum learning material uses basic objects such as cubes, cylinders, and planes. To design an object using blender software using several techniques, namely extrude, scale, drag or move, rotate and loop cut slide techniques are also used in modelling this learning object. Extrude functions to shape or pull certain parts in an object. Scale functions to scale (Shrink and zoom in) an object or part of an object. Drag is used to slide objects to the desired area. Rotate works to rotate or rotate objects. Loop Cut Slide functions to divide objects into parts, which can be done by pressing the CTRL+R keys.

After doing the animation simulation, it can be seen from the animation display in the Virtual Reality Box that it works well and the objects displayed look perfect and clear. When the Step 1 Fiber optic learning animation gives the command "Step 1" , then the practicum will begin. Then select the Fiber optic cable 1, then the Stripper will move to cut and peel the Fiber Optic 1 cable, then click the Fiber Optic 2 cable, then the Stripper will move to cut and peel the Fiber Optic 2 cable.

Likewise so on to each Fiber Optic learning material. In the display image step 2 results in the Fiber Optic cable has been peeled off. Then click Cleaver, then Cleaver will move to open to insert Fiber Optic cables one by one, then immediately close to cut the Fiber Optic fibers.

In the image of display 3 produces a fiber optic cable that has been cut. Then click the splicer, then the splicer will move open to insert the two Fiber Optic cables, then directly close to connect the fiber Optic cable into one. After the fiber optic cable is connected, close the connection using Protection Sleave to protect the fiber.

In the image of display 4 it produces a Fiber Optic cable that has been cut, peeled, connected and covered by Protection Sleave. Next, click Router Board, then it will move to pair the patch core 1 to the Router Board, then click OPM, then OPM will move to pair patch core 2, the purpose is to measure the voltage in the Fiber Optic cable, if the voltage is close to 0 then the Fiber Optic cable is said to be good and if the voltage is very far from the number 0 then the Fiber Optic cable is said to be bad.

This animation is done by adding a keyframe to the object you want to animate. Adding keyframes makes objects look more real. The response speed of the animation movement is determined by the animation settings of the laptop or pc used. If the laptop

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or PC has low specifications, then the response from the animation will also be slow and vice versa. If the laptop or pc has high specifications, the response from the animation will also be fast.

The creation of 3D object animations in the Fiber Optic Practicum Learning uses the functions in the Verge 3D software. The functions used are as follows.

a. When click, do …
   It works to do something by clicking on a specific object.
b. Play Animation
   Functions to move animations according to basic animations made in the blender software.
c. Hide
   Serves to hide certain objects.
d. Show
   Functions to display specific objects.
e. Snap
   Set the selected object or vice versa.
f. If… do…
   It functions to do something with certain conditions.
g. After… second(s) do…
   It serves to do something after a certain time.

After the process of compiling the puzzles on the 3D verge, the saved files will be uploaded to the WordPress application which is a flatform for creating blogs and websites. So that this animation can be accessed directly and can be seen clearly using VR glasses

The creation of 3D object animations in Indonesian and Mathematics subjects uses functions in the Verge 3D software. The functions used are as follows.

h. When click, do …
   It works to do something by clicking on a specific object.
i. Play Animation
   Functions to move animations according to basic animations made in the blender software.
j. Hide
   Serves to hide certain objects.
k. Show
   Functions to display specific objects.
l. Snap
   Set the selected object or vice versa.
m. If… do…
   It functions to do something with certain conditions.
n. After… second(s) do…
   It serves to do something after a certain time.

After the process of compiling the puzzles on the 3D verge, the saved files will be uploaded to the WordPress application which is a flatform for creating blogs and websites. So that this animation can be accessed directly and can be seen clearly using kacam.

D. Discussion

The results of the study show that the Virtual Reality-based Fiber Optic practicum learning media developed can function well and is able to simulate the stages of the practicum according to laboratory procedures, ranging from cable stripping, cutting, connecting, to measure using an Optical Power Meter (OPM). All system features can be executed well in a virtual environment.

The use of Blender and Verge3D produces realistic and interactive 3D visualizations, so students can understand the function of the tool and the sequence of practicum procedures correctly. This media not only serves as a visualization tool, but also as a procedural learning medium that supports students' readiness before conducting practicum directly in the laboratory. Compared to previous research, this media has the advantage of presenting a more complete simulation of Fiber Optic practicum.

Ariatama et al.'s research is still limited to 2D VR, while Musril et al. have not included interactive procedural simulations. Lestari et al.'s research has developed interactive VR media, but it does not include the technical stages and practicum measurement as a whole. Therefore, the media developed in this study has a higher practical relevance in Fiber Optic practicum learning.

IV. CONCLUSION

Based on the results of the research and discussion, it can be concluded that Virtual Reality-based Fiber Optic practicum learning media with interactive 3D animation is able to simulate the stages of practicum systematically, starting from cutting, stripping, cable connection, to measurement using Optical Power Meter (OPM), so that it not only functions as a visualization medium but also as a procedural learning medium that is close to real laboratory conditions. The main contribution of this research lies in the development of Virtual Reality media that presents a complete and interactive simulation of Fiber Optic practicum up to the measurement stage, which can increase student readiness before direct practicum, especially in the condition of limited laboratory facilities. However, this research is still limited to functional testing and usability, so further research is recommended to examine the influence of this media on the improvement of student learning outcomes quantitatively and expand its application to other practicum materials.

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