Virtual Reality Development Support Tools for Industrial Training Systems in Indonesian Vocational Education

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Abstract—**This study aims to create a Virtual Reality-based Industrial Training Simulation in Vocational Education. A research and development model is used in this study. Design This virtual reality-based industrial training employs the Multimedia Development Life Cycle method, which consists of six stages: concept, design, material content collection, assembly, testing, and distribution. Devices that support the development of virtual reality for simulation of industrial training in the electronics sector, particularly in the field of instrument and control operators, include hardware, software, and human perception; virtual reality-based training simulations have an impact and can be used as one of the main facilitators to assist schools, the Indonesian government, and industry in fulfilling vocational education competencies, so that there is a link and there is a link and there is a link and there is a link and there is a link and there is a link and match to the need for the world of work. The use of virtual-based Industrial Training is used. The following are four (four) key elements for those who build virtual reality systems: i) virtual environment; ii) immersion; iii) feedback; and iv) interactivity. Virtual reality is a new technology that is being used in the field of education because it has its own set of benefits, including high quality and feasibility. This Virtual Reality-based industrial training platform will continue to be developed and implemented in Indonesia as soon as possible.**

Index Terms—**Tools, Virtual Reality, Training, Industry, Vocational School**

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I. INTRODUCTION

Vocational education, according to [1], is a holistic experience notion for every person who learns to succeed in the workplace. In this instance, vocational education teaches students a lot about becoming ready for the workforce. In addition, Law No. 20 of 2003 Concerning the National Education System stipulates that vocational education is defined as education that specifically prepares students to work in a certain profession while simultaneously preparing them to continue their education to a higher degree.

The curriculum for vocational education and general education are undoubtedly distinct. The vocational education curriculum should ideally accommodate all aspects of each individual until he is ready to work in a company. The evolution of the vocational education curriculum as follows [2]:
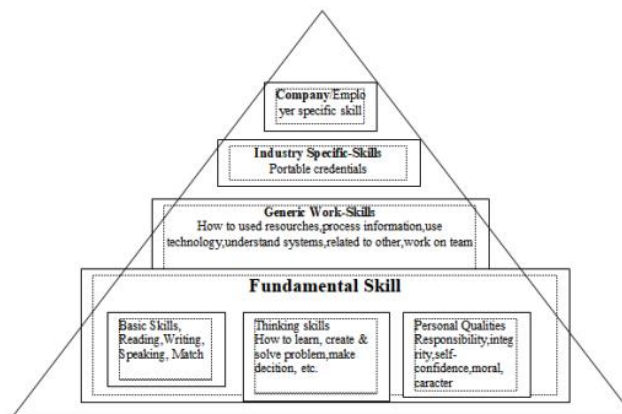

Fig 1. Structure Development of Vocational Education and Training Skills

Basic vocational education skills become an extremely important foundation for one's career development (Figure 1). These fundamental skills serve as the foundation for each individual's abilities, thinking abilities, and qualities. Following the basic skills listed above, here is how to prepare for the needs of resources, information and technology, systems, relationships, and teamwork. Following that, students will work in a specific industry. As a result, workers can develop more advanced skills. The curriculum is designed to be constantly updated. The curriculum for vocational education must be relevant to the advancement of science, technology, and the arts (IPTEKS). Vocational Education Training (VET) can accommodate a wide range of values, including technological, economic, cultural, social, and political aspects, as well as learning itself. In its evolution, vocational education at the secondary education level is still referred to as vocational education, as is vocational education at the higher education level. Currently, the Vocational Education Program in Indonesia is divided into a 3-year education program and a 4-year education

program, according to regulations. However, only 12 of the 12,848 vocational Schools are four-year programs. There are 9 Expertise Fields, 48 Expertise Programs, and 142 Expertise Packages developed. Aside from vocational education (and training) that occurs prior to entering the workforce (pre-service training or pre-service training), there is vocational training that occurs after graduates enter the workforce. Companies, industries, or workplaces provide this type of training to prepare new employees to master skills that are truly relevant to the workplace they enter.

This business requires Vocational High Schools to be able to adapt to the Industrial World Business World, but Vocational Schools also require large investment costs, because Vocational Schools require practical facilities in the form of buildings, machines, equipment, and other practice support facilities, as well as high operational costs. Efforts to increase the number of vocational students in order to achieve a comparison of 70% of vocational students and 30% of high school students are carried out, among other things, through partnerships or collaboration with industry, with the goal of continuously increasing the number of vocational students while also improving the quality of vocational schools.

This is consistent with the educational principles described by Charles Prosser (1925) in [3] that there are 16 principles that can be put forward in vocational education, three of which are related to the role of industry. Vocational education will be effective if (1) training tasks are carried out using the same means, tools, and machines as those prescribed in the workplace, and (2) it trains a person in the habit of thinking and working as required in the job. (3) Vocational education will be more effective if the environment in which students are trained is a replica of the environment in which they will work later in their careers. This efficiency is achieved because the industry no longer needs to organize training centers. Vocational schools require very high costs to fulfill these three principles, especially if they want to fulfill all of Prosser's principles [4].

Realizing this condition is difficult due to the government's limited funds for the development of practice facilities. This creates a supply-demand imbalance between SMK and industry. To address this issue, a media application for training programs is being developed.

Media for training programs is a manipulable tool that can be used to influence students' thoughts, feelings, concerns, and attitudes, thereby facilitating the training process [5]. The use of media in the training process can generate motivation to learn, new desires and interests for students, and even psychological effects on students. Students can use the media to find and obtain the necessary sources of information without relying on the learning resources provided by the teacher [6].

The goal of media development is to create training materials that are based on existing development theories [7]. In this case, researchers will create training media based on virtual reality [8]. Virtual reality is a combination of real-time interactive graphics with three-dimensional models and screen technology that can provide users with experiences such as entering a virtual world and manipulating it directly. Virtual reality is a novel approach that allows users to interact with computer simulations.

II. STUDY LITERATURE

A. Occupational Education and Training

Education and Training (DIKLAT) in general aims to provide opportunities for personnel to improve their skills and abilities, particularly in areas related to leadership or management required to achieve organizational goals. Understanding education in general is a conscious and planned effort to create a learning environment and learning process in which students actively develop their potential for spiritual strength, self-control, personality, intelligence, noble character, and necessary skills. Meanwhile, training is defined as an organization's planned effort to facilitate employee learning on job-related competencies. Training is generally intended to improve mastery of various job skills in a relatively short period of time. Education includes training. Training is focused, practical, and timely. Specific means that the training is relevant to the work performed. What has been practiced can be put into practice in a practical and immediate manner. The following are the goals of education and training (training): 1). Training is designed to improve employee performance in the workplace. 2. Education and training are expected to shape employees' attitudes and behavior in the course of their work. Emphasis is placed on increasing employee participation, employee cooperation, and organizational loyalty. 3. Education and training aid in the resolution of day-to-day organizational operational issues such as reducing work accidents, absenteeism, and labor turnover, among others. 4. Education and training have a short-term and long-term goal, which is to prepare employees to acquire expertise in certain fields required by the company. 5. It is hoped that through Education/Training (Training), employees will have high abilities and knowledge, making them more valuable to the organization. 6. With education and training, employees will be able to acquire skills in a shorter period of time, and they will be able to adapt to the work they face more quickly.

The Education and Training Method (Diklat) is a systematic approach that can provide a broad description and condition the implementation of training (Pusdiklat) to develop the workforce's cognitive, effective, and psychomotor aspects toward their duties and work [9]. Education includes training. Training is focused, practical, and timely. Specific means that the training is relevant to the work performed. What has been practiced can be put into practice in a practical and immediate manner. Training is generally intended to improve mastery of various job skills in a relatively short period of time. The training method or training consists of five ways: a. Work, in this method, trainees work directly on the job site to learn and mimic a job under the supervision of a supervisor. The benefit of this method is that it provides participants with a lot of new things to learn. The success of this method is entirely dependent on the trainer. b. Indoors, the training method is typically used by industrial companies to introduce jobs to

new employees and train them to introduce the job. Typically, work training is provided here. c. Role-playing and demonstration, training methods that involve demonstrating and explaining how to do a job using examples or experiments. Usually equipped with lectures, pictures, videos, and so on, d. Simulation, a technique for imitating the actual concept of the work to be encountered as closely as possible. Through simulation, the appearance of situations or events that are as close to the actual situation as possible, even if only an imitation, e. Internships are a great way for employees to learn about all aspects of their jobs.

Among other things, a task includes names and descriptions of steps of a task, an initial situation, an objective (criterion for the success of the work performed), constraints to be observed (as criteria, the violation of which constitutes an error) and an ideal solution (procedure). Trainees are supported by different training modes (Figure 2), which require different activities [10]: 1) Discovery Mode Acquisition of background knowledge and experience by "playing around" No task, no procedure to be performed Freely manipulable visualization of a functioning system 2) Presentation Mode The procedure demonstrates how professionals would complete the task at hand. The presentation is comparable to an interactive video in which users can determine their progress on their own. Users may diverge to acquire more details on specific topics and also select different viewpoints.
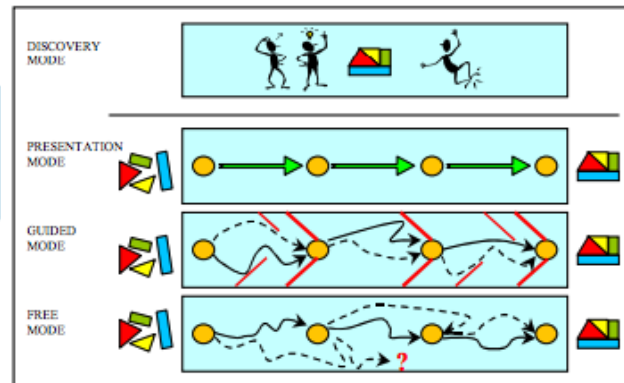

Fig 2. Training modes

3) Guided Mode Applying the knowledge acquired in the presentation mode, the guided tour defines concrete tasks a trainee has to perform. The trainee receives hints and explanations related to the task. The system specifies the sequence of subtasks. 4) Free Mode Trainees are not provided any specified procedure to complete the task. The training objective to be achieved emphasizes independent action and comprehension of casualties. Users may take advantage of free manipulation. They may make errors and the system evaluates them. Numerous existing prototype solutions have demonstrated that the options for training staff with the support of virtual training systems hold great didactic and economic potential. The use of real machinery and plants for training frequently incurs considerable expenses. The creation of three-dimensional models during product development and plant engineering is very advanced in industry. Integrated utilization of design data not only for planning, development and manufacturing but also for the generation of VR systems provides a broad basis for their cost effective use in the widest variety of learning processes.

B.   Virtual Reality

Due to technological advancements, information media is now shifting to Virtual Reality (VR) media [11]. Virtual reality [12] is the appearance of three-dimensional images created by a computer that appear real with the help of special equipment, giving the user the impression that he or she is directly physically involved in the environment [13]. With the advancement of mobile technology that can serve as a medium, virtual reality has evolved into an interacting concept that is quite simple to use [14]. At the moment, only mobile devices and Google Cardboard can display VR content. Several VR roles, such as simulation, interactive learning, promotion, and games, are increasingly being developed [15].
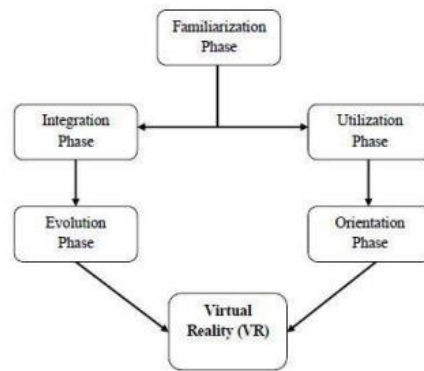
Fig 3. VR recognition and implementation process Source

Meanwhile, in the realm of education, it can be done in a more intensive way between the government and the industry related to teachers. According to Hooper in [16], explaining the discussion in the process of introducing and implementing learning using Virtual Reality (VR) can be done by implementing several steps, namely familiarization, utilization, integration, reorientation, and evolution. Where can be clearly described as follows; To begin, Familiarization is a level in which teachers will be taught to understand the processes and steps involved in using Virtual Reality (VR) technology. Second, educators will begin to experiment with using Virtual Reality (VR) in the process of teaching and learning activities at the Utilization level. Third, Integration is a stage in which educators begin to experiment with Virtual Reality (VR) by collaborating on curriculum development. At this level, educators will begin to design related scenarios in the target competency criteria for teaching and learning activities on their own, and they will be responsible for the success of using Virtual Reality (VR) in learning activities. Fourth, reorientation, at this level educators begin to consider and attempt to re-conceptualize the purposes and functions of learning carried out, at this level an educator can also become a knowledge center or simply want to be a facilitator. Furthermore, students will become subjects in the process of teaching and learning activities at this level, rather than objects being taught by educators. The final level, or Fifth, or what is commonly referred to as the Evolution level, requires schools to be involved in the adoption of Virtual Reality (VR) so that learning process activities continue to prioritize effective aspects in the process of sustainability.

Virtual reality, according to Steven, is an artificial sensor stimulation used to induce a person into a simulation [17]. VR is defined by four (four) main keys [17]: 1. Specific Behavior The creator will design an experience for the target. Flying, walking, exploring, interacting, and so on are some examples. 2. Microorganisms Can be from the perspective of other people, cats, cockroaches, birds, and other organisms. 3. Synthetic Sensory Stimulation Engineering (engineers) allows a person to physically transform into something desired. 4. Consciousness Users will feel as if they are in an "other" world created by the creator when they engage in a VR experience.
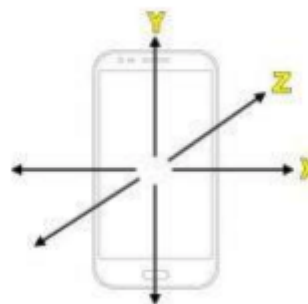

Fig 4. Illustration of Accelerometer on Smartphone

Fig 5. Illustration of Gyroscope on Smartphone

This accelerometer, as the name implies, measures the acceleration that the device experiences relative to the three XYZ axes, or right, left, up, down, and flat. This information is used by the system or an application to determine whether the smartphone is in portrait or landscape mode. A gyroscope, also known as a gyro, is a device that measures or maintains orientation using the angular momentum determination principle. The gyroscope sensor determines motion orientation by resting on a wheel or disc that rapidly rotates on an axis [18]. This tool can provide orientation information, but only up to 360 degrees of rotation on the phone.

III. RESEARCH METHODOLOGY

Research and development, sometimes known as R&D, is a research methodology. Instead of testing or developing theories, R&D in education aims to create more useful teaching tools. A virtual reality-based industrial training simulation is what this study wants to create. This program aims to develop students' skills as a source of information before they enter the workforce. This multimedia development life cycle-based industrial training design makes use of virtual reality [19]. The Multimedia Development Life Cycle (MDLC) development model has six stages: concept, design, material content collection, assembly, testing, and distribution. The Multimedia Development Life Cycle (MDLC) Method Flow The purpose of the concept stage is to determine the type of application, target user, and purpose of media creation. The concept of learning in the form of simulations on the training component as a medium and to support vocational education student training activities is central to the development of industrial training media based on Virtual Reality on the Instrument Operator and Control test material.

IV. RESULTS AND DISCUSSION

C.   Electronics Education

Electronics is a branch of electrical engineering that discusses weak current electrical devices that work by controlling the flow of electrons or charged particles from an electric charge source in an electronic device such as a radio. , television, computer, and other electronic devices Electronics study cannot be separated from knowledge of electronic components made/available on the market. Electronic components are assembled to form an electronic system/equipment that controls electrons from an electron source so that they can work in accordance with the desired circuit design.
The following are some of the vocational education trainings that have been held (Table 1)

Tabel 1. Types of Electronic Training Implementation

No	Department	Type of Training
1	Electronics Engineering	1. Fiber Optic Technician, 2. Audio Video Technician, 3. Cell Phone Technician, 4. Industrial Electronics Automation Operators, 5. V-SAT Technician, Surface Mount Technology, 6. Instrument Operators and Controls

According to table 1, the type of training provided to students in this study is at point no. 6, namely instrument and control operators with competencies in: 1) identifying electronic components; 2) using a multimeter/avo to measure voltage, current, and resistance; 3) using an oscilloscope to measure voltage and frequency; 4) manual wiring harness assembly; and 5) installation of the relay sequence controller circuit.

D. *Media Product for Virtual Reality (VR)*

The training media displays learning simulations that are designed to look like the original form, allowing students to quickly grasp the material. Additionally, students can take measurements using the provided components. Because the media file is in.apk format, the use of this media requires the use of a Smartphone for installation, as well as a VR Box device and a controller to run it.

Fig 6. Utilization of VR BOX

E. *Devices of Virtual Reality (VR)*

To experience the true sensation of VR technology, additional devices are required. This device is made up of VR Box glasses, a headset, a walker, a suit, and gloves. Virtual reality technology necessitates several factors, including: 1) Display images / graphics / 3D visualization appear real and in accordance with the user's perspective; 2) Capable of detecting all user movements and responses, such as head or eyeball movement. This is required so that the graphical display can keep up with the user's changing 3D world. These devices seek to engage as many senses as humans do. The involvement of many senses in VR will be directly proportional to the increase in the level of real sensation of the virtual world. The following will explain some of the supporters in virtual reality.

1. Hardware

The hardware will generate stimuli based on movement that will outperform the student's senses. Students operate by tracking student movements such as button presses, controller movements, eye movements, and other body parts with sensors. Personal Computer (PC) / console / smartphone are examples of hardware. Computers are used to sequentially process input and output. Input devices give students a sense of immersion and help them figure out how to communicate with the computer. This assists students in navigating and interacting in the VR environment, making it as natural and intuitive as possible. Joysticks, force balls/tracking balls, controller sticks, data gloves, trackpads, On-device control buttons, motion trackers, bodysuits, treadmills, and motion platforms are the most commonly used input devices. The output device, on the other hand, is used to present VR content or environments to users and is the best device for producing immersive feelings such as audio visual display.

VR requires two main devices for its application: hardware and software. The hardware serves as a container for the Smartphone as well as a tool for visualizing VR objects generated by the Smartphone screen. The software creates three-dimensional objects or images that are then transferred and displayed on the Smartphone. The following hardware can be used to support VR simulation activities:

1. Virtual Reality Headset (VR Glasses) or Virtual Reality Smartphone The main features of this VR Headset for Smartphone are that it has a slot or place to insert the Smartphone into the VR glasses.

Figure 7. VR Box

2. mobile phone or smartphone (Android). The primary requirement for a smartphone that can be used is that it have a Gyroscope feature.
3. Earphones or headphone To feel the sound produced by the ongoing VR simulation as a supplement to the sound.
4. Control via remote. Serves as a controller for the currently running simulation. Bluetooth is used by the majority of devices.

Figure 8. Bluetooth Remote Control

1. In addition to the devices listed above, several other supporting devices can be used to create a more realistic experience. Among these devices are: 1. Gamepads or joysticks 2. Tracking balls or force balls 3. Remote control wands four. data gloves 5. Speech recognition 6. Bodysuits or motion trackers Treadmills (7)

Fig 9. VR Input Device

2. Software

The software analyzes the incoming data and provides appropriate feedback. The entire application is time-critical, and the software must be able to manage it, which means that the input data must be handled quickly, and the virtual reality-based training response sent to the output display must be quick and precise.

a. Android

Android is a modified Linux-based mobile operating system that includes an operating system, middleware, and main applications. Because Android was created by Google, it contains a large number of free applications.

The convenience of programming languages such as Java, which is Java code that is compiled together with the data and resource files required by the application, which are combined by aapt tools into an android package, led to the selection of an android application. These training files are identified by the extension (.apk). This file is an application that is installed on a mobile device. Smartphone criteria that can be used for industrial training simulations based on Virtual Reality (VR) include smartphones with gyroscope and accelerometer sensors, which almost all smartphones now have.

b. Blender

Blender is a free and open source program for creating three-dimensional animations. Blender is used to create animations, visual effects, 3D printed models, and interactive 3D applications for industrial training simulations. Blender was chosen for virtual reality training because it has many features such as rigging, animation, simulation, rendering, compositing, and motion tracking, as well as video editing and game creation.

c. MilleaLab

MilleaLab is a complete software platform for developing industrial training content in 3D and virtual reality. Without coding skills, the cloud-based platform provides hundreds of templates and 3D models for creating virtual-based industrial training tailored to industry conditions. MilleaLab is intended to make training activities more interesting, innovative, and imaginative, as well as to support lecturers in their efforts to innovate in training by developing VR-based industrial training.

a) Unity 3D

Unity 3D is a game engine that runs on multiple platforms. Unity is used to develop a VR-based industrial training system that can be accessed via computers, Android smartphones, iPhones, PS3, and even XBOX. Unity is extremely simple to use; simply create a training simulation view and you will be given a function to run the object. There are variables in every frame of industrial training; these variables must be understood in order to create a quality industrial training system. The first section in Unity is assets, which is a repository in Unity that stores sounds, images, videos, and textures. Following that is the scenes section, which contains content from industrial training such as creating a level, creating menus, creating waiting displays, and so on. Following that is the training object section, which includes measuring tools and other components, namely items in assets that are moved into scenes and can be moved, resized, and rotated. The final section contains components, which are new reactions for objects such as collisions, particle generation, and so on.

The creation of a visualization in the Virtual Reality (VR) world can begin with a sketch of the shape of the room, followed by modeling efforts in 3D dimensions with the help of Blender and 3Ds Max software (Figure 2).

Fig 10. Room Virtual

The function in this case is to be able to bring up an object that will be inserted into a Virtual Reality (VR) media using the Google Cardboard SDK. Furthermore, the training content arrangement will be used as an information medium for industry rooms via a JSON file. Whereas a form-based website is used to handle dynamic training content in the form of JSON files [20]. So that the implementation is applied to a 3D object and JSON-shaped file as one of the industry training room's information efforts, and then produces an industrial training application based on Virtual Reality (VR) that is published in the form of mobile application

3. Student Perception

Understanding human body physiology and optical illusions is critical for achieving maximum human perception with minimal side effects. Different stimuli, receptors, and sense organs are used by the human senses. Because virtual reality is intended to simulate the real world, i.e. according to industry conditions, it is critical to understand how to "trick the user's senses" into knowing what stimuli are most important and what display equipment quality is acceptable. Human vision transmits the majority of information to the brain, followed by hearing, touch, and other senses. The correct use of VR-based industrial training is also dependent on the synchronization of developed industrial training and all stimuli with student actions.

The main features that are directly related to the process of exploring existing equipment in the industry for training are the camera movement and navigation features. The user can walk forward with a slight head tilt and stop when the head is lifted back up. In this way, VR users do not need to press any buttons on their controller to walk around and explore VR. This walking motion detects the angle using sensors on the mobile device's gyroscope.
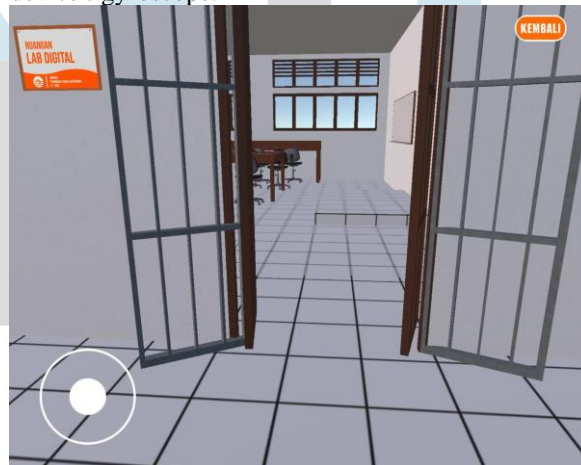

Fig 11. Navigate to the Virtual Reality Training Room

The target area in the training room should be designed in the form of simple geometric shapes because it will later be used to display training equipment. To provide a feature for users to move or find equipment without using a controller, the position of the VR camera is pointed at 30 degrees. This degree number can be adjusted to adjust the user's walking motion supported by the gyroscope feature on mobile using the Google VR SDK.

According to [21], the advent of Virtual Reality (VR) technology allows humans to feel in a place with a real-like sensation and an overall appearance, making it easier to know what kinds of objects are clearly and real.

F.   *Important Factors to Consider When Using Virtual Reality-Based Industrial Training*

1. A virtual world is a three-dimensional environment made possible by training media. As part of that interaction, students can interact with other students and take component measurements or carry out activities that are commonly carried out in the industry.

Figure 12. Virtual world with three-dimensional object

2. Immersion is the perception of being physically present in the non-physical world, a sensation created by VR technology to allow students to feel as if they are in a real environment when they are not. Immersion is classified into three types:
a. Mental immersion, involves making mental students feel as if they are in a real environment.
b. Physical immersion, which allows students to physically feel the atmosphere created by virtual reality.
c. Students' mental immersion, in the virtual reality environment generates the sensation of dissolving.

Figure 13. Control Training Media with hand movement

3. Sensory Perception Virtual reality training necessitates the use of as many of the student's senses as possible. Sight (visual), hearing (aural), touch (haptic), and other senses are included. These stimuli necessitate sensory feedback, which is provided by integrated hardware and software.
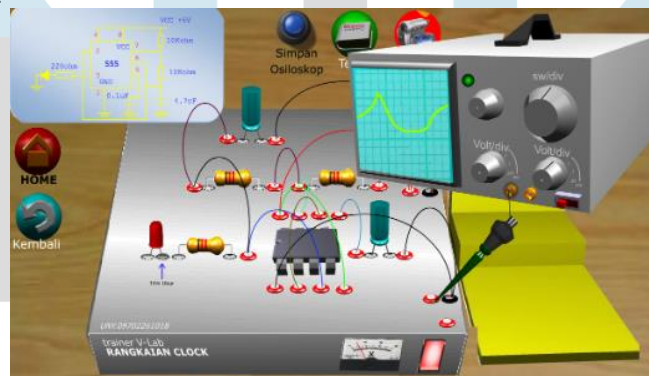

Figure 14. Visualization of Virtual Reality

4 Interactivity
Assigned to respond to student actions in order for students to interact directly in fictitious fields. Interaction is required for the virtual reality experience to provide students with enough comfort to engage with the virtual environment naturally. The excitement and sense of immersion will be maintained if the virtual environment responds to user actions in a natural manner. If the virtual environment does not respond quickly enough, the human brain will notice and the sense of immersion will be diminished. Interactivity describes how students can participate in changing the form and content of the training simulation. Interactivity is influenced by three factors:
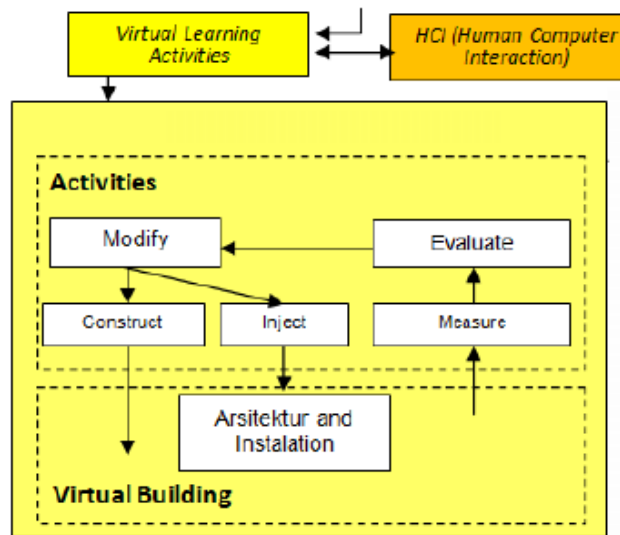
Fig 15. Interactivity [22] at Industrial Training.

G.   *Evaluation of the Effectiveness of Industrial Training Simulation Media Based on Virtual Reality*

Questionnaires were distributed to student respondents in field trials to test the effectiveness of Virtual Reality products. One method for determining the model's effectiveness and practicality is to assess experts and practitioners based on the results of their mastery of theory and experience in determining whether or not the Virtual Reality industry training media is effective. Figure 5 depicts the results of the questionnaire assessment of the product's effectiveness.
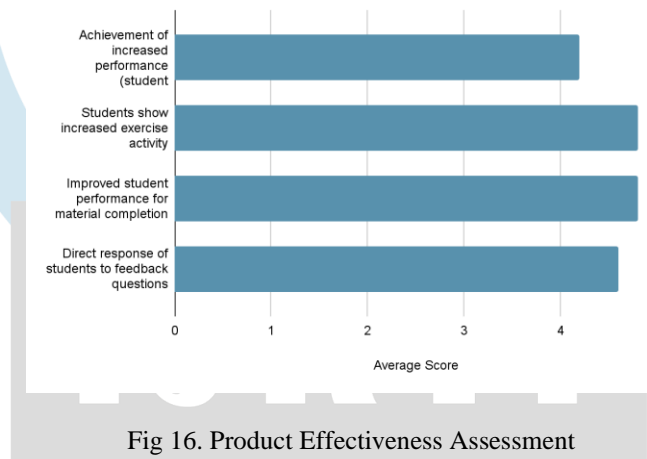

Fig 16. Product Effectiveness Assessment

Figure 5 shows that several assessment indicators for job improvement (teachers' competence) received an average score of 4.2 or were in the good category when used to evaluate the effectiveness of the Virtual Reality industrial training simulation media product. The evaluation of the increase in student activity received an average score of 4.8, placing it in the very good category. The evaluation of the improvement in student performance for completing the material received a score of 4.8, placing it in the very good category. Furthermore, the assessment of students' direct responses to feedback questions given during the training process received an average score of 4.6, indicating that they were in the very good category. Finally, the assessment of student responses by asking questions or raising their hands received a score of 4.4, placing them in the good category. As a result, the product's overall average effectiveness received a score of 4.56, placing it in the very good category. This means that the product developed in response to student feedback meets the criteria for excellent product effectiveness.

V. CONCLUSIONS

1.   Hardware, software, and human perception are used to support the development of virtual reality for training simulations in the electronics industry, particularly in the field of instrument and control operators.
2.   Virtual reality-based training simulations have an impact and can be used as one of the primary facilitators to assist schools, the Indonesian government, and industry in fulfilling vocational education competencies so that there is a link and match to the needs of the workplace.
3.   Application of virtual-based Industrial Training There are four key elements that make up a virtual reality system:

i) virtual environment; ii) immersion; iii) feedback; and iv) interactivity.

4.   Virtual reality is a new technology that is being used in the field of education because it has its own set of benefits, including high quality and feasibility.

5.   This Virtual Reality-based industrial training platform will be further developed and implemented in Indonesia as soon as possible.

VI. ACKNOWLEDGMENT

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