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Effectiveness of Using Virtual Reality Media for Students' Knowledge and Practice Skills in Practical Learning

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Abstract— **Virtual Reality (VR) has become an option to be used as a learning medium in engineering. A study of the effectiveness of VR is needed to determine which fields and types of learning are suitable to employ it. This work aims to reveal the effectiveness of virtual reality media on students' cognitive and practice skills. The role of the media as a tool to make learning more efficient and effective. VR media brings learning in the virtual world that seems to be done in real terms. The research method used was a quasi-experiment with a posttest-only control group design research approach. The research subject consisted of two homogeneous classes. Learning outcomes are evaluated by testing students' cognitive and practice skills. The novelty of this research is the creation of learning media that are identical to the welding process simulator. Visual practice places and equipment in virtual form through VR are made to resemble practice places and equipment used in real situations. This similarity aims to provide concrete information about the welding process. The study revealed that the use of VR media significantly affected their knowledge. However, it did not significantly affect their practice skills. VR has not been able to provide an experience closer to real-life conditions during welding, such as heat, sparks, and sounds that appear when the electrode touches the workpiece. The distance between the electrode and the workpiece significantly affects the welding result in the welding process.**

Keywords— **Learning media; virtual reality; practical learning; welding techniques.**

I. INTRODUCTION

The development of equipment technology for production in the industry is very fast because it pursues a large number of production targets to get big profits and superior product quality to compete in the market. To prepare the graduates to be ready to work with existing technology in the industry, the equipment or machines that become learning media at universities must be the same as those in the industry. It is difficult for the university because it costs much money [1].

Technology is made to facilitate human work in processes and results that can provide information and knowledge. Technology is a form of scientific implementation in a structured manner that can complete practical tasks. Technological developments have an impact on effective and efficient problem-solving [2]. In education, technology is necessary to coordinate people, ideas, procedures, and results from the implementation of education. All activities in education can be controlled with technology so that the achievement of educational goals can be projected clearly. [3].

Currently, virtual reality technology that can visualize equipment, machines, and the shape of a laboratory room has been developed. VR is interactive, immersion (immersing or inserting), and real-time and virtual objects are usually in 3 dimensions [4]. VR combines real objects into a virtual world or virtual environment. The use of VR for learning media can meet the needs of universities that lack machines and equipment. VR as a learning media can be used with only mobile and cardboard. Based on Statcounter GlobalStats, mobile users are the highest in the world at 60.73% [5].

For mechanical and electrical engineering, VR is a new trend in education. However, the use of VR still needs to be studied in specific fields to reveal its effectiveness. Studies have proved that VR use in undergraduate mechanical engineering courses as a teaching supplement can increase student confidence when using equipment for the first time [6]. VR in the project-based learning model classes significantly improves students' communication and problem-solving skills. Furthermore, a review of several articles reporting on VR use for learning in engineering education found that the evaluation was unclear, and the virtual scenario

was unrealistic. Therefore, it needed further investigation. The results of the bibliometric analysis reveal an increasing trend of research related to VR in engineering education [7].

Based on the literature review, VR can be used as a learning medium and needs trial in various courses. Thus, it can add references to using VR as a learning medium. More reports on research about the application of VR as a learning medium in various courses will be more helpful in making conclusions about its effectiveness in general. The previous research on VR effectiveness as a new learning medium revealed that it could increase students' confidence in using equipment for the first time, improving students' communication and problem-solving skills [8]. This research was conducted in the welding technology course at the Mechanical Engineering major. For this course, no study reports the effectiveness of using VR. Another novelty of this research is that it studies student practice skills after learning VR media. The latest paper on using VR in engineering education is only related to increasing students' understanding of the subject [9]. The review paper also revealed that VR as a new learning media only improves students' cognitive aspects. Therefore, this research is very reasonable and helpful for assessing the use of VR as a learning media. So, Virtual Reality (VR) technology is a way to display learning images in the form of three-dimensional media or 3D, which is made with the help of a computer so that the results will looks like real. This will make its users (students) feel as if they will see directly and physically in a different environment predetermined.

The virtual world's design in Virtual Reality can make the user's imagination appear real. Virtual Reality provides images and aspects of movement in real form. The drawback of virtual Reality lies in conveying the sense aspects to its users so that the application of virtual reality media in learning is able to provide concrete knowledge, attitudes, and psychomotor skills. To fulfill the real knowledge aspect, the design of learning conditions is adapted to the real conditions of the learning environment [10].

Virtual Reality that develops for educational media [11] consists of several forms:

1) Immersive First Person: or what is often called a head-mounted display (HMD), the hallmark of this model is the use of optical gloves and a 3D audio system. This model can provide a fast user experience.

2) Augmented Reality: This model is an additional model capable of displaying computer graphics resembling translucent holograms in the real world to increase user understanding in understanding the aspects being studied.

3) Virtual Reality through the Window. This is a virtual reality model that is often used in games. The advantage of this model is that it can improve users' problem-solving ability. Usually, the learning orientation that uses this media is problem-solving-based learning.

4) Second person: This model can capture images and integrate them in virtual form on virtual reality media. Users can see themselves carrying out the observation process in cyberspace on the monitor that has been provided.

5) Telepresence. This virtual reality model is capable of visualizing distant views in virtual worlds. Implementing its

application in robotic systems to complete dangerous tasks and beyond human capabilities. This media is sensor-based and controlled by the operator as a user of virtual reality media.

6) Mix Reality. This model combines telepresence systems and Virtual Reality so that the experience gained by users of this media is in the form of a process simulation.

Technological collaboration in educational elements will overcome existing problems in implementing education. This is a big problem in practical learning because it can hinder the transfer of competence to students [12]. Learning metal welding technology, which is practical learning and must be followed by all students majoring in mechanical engineering, requires students to learn offline or face-to-face. The strategy used at this time is based on the policy of the university leadership in implementing practicum lectures carried out by reducing the capacity and intensity of students in learning. A possible solution in these conditions is the creation of an animated virtual learning container using VR tools. This tool will provide a real picture of the process and welding procedures that are the same as in the real world. The importance of achieving welding competence requires students to be active and creative. Welding psychomotor skills will be more mastered if students often practice them. If the intensity of learning is reduced because the goal is to prevent the spread of the virus, innovation and creativity are needed to overcome this problem, and learning objectives can be achieved.

II. MATERIAL AND METHOD

The study was conducted using a posttest-only control group design (Fig. 1) [13]. The research was carried out in two classes with the same subject, namely welding technology. One used conventional media such as whiteboards and slide presentations (Class A) with 16 students.
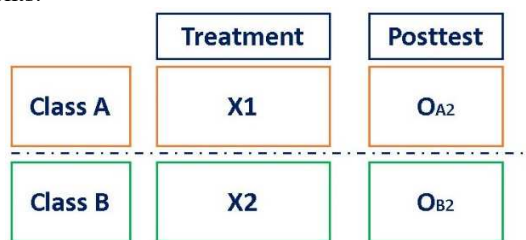

Fig. 1 Posttest only control groups design

Another one used VR learning media (Class B) with the same number of students. This study figures out VR's effectiveness as a learning media by comparing it with conventional media related to students' understanding and practice skills. The components of the assessment of students' welding knowledge and practice skills are presented in Table 1. Students' cognitive skills are obtained from ten essay questions. The suitability of the question content with the learning material was validated by content by four lecturers who have experience in teaching welding technology. The reliability is tested by giving a trial test to 20 students who participated in welding technology learning. Based on the Cronbach alpha analysis, the value was 0.892. Cronbach's alpha with a value of more than 0.7 is sufficient [14].

TABLE I
COMPONENTS OF ASSESSMENT OF WELDING KNOWLEDGE AND PRACTICE SKILLS

Component	Indicator	Validity	Reliability
Knowledge	Welding health and safety		
	Welding process equipment and support		
	Electrode		
	Welding machine setting		0.892
	1G position downhand welding procedure		
	Welding visual inspection		
Practice Skills	Using personal protective equipment		
	Use of equipment according to its function		
	Welding machine setting	0.84	
	1G position welding process		
	Visual inspection of welding results		
	Welding result		

The assessment of student practice skills is carried out using an assessment rubric. The value in the rubric has a range of 1 to 5. The validation of the rubric instrument for assessing practice skills is carried out by four lecturers who are experienced in teaching welding technology. Data from lecturer validation on student practice skills assessment instruments were analyzed using the V coefficients formulation [15]. The results of the data validation analysis obtained a value of 0.83. It means that the students practice skills assessment instrument is feasible to use.

Data analysis of students' cognitive skills and practice skills assessments was analyzed using an independent sample t-test and Mann-Whitney analysis [16]. This test aims to compare the averages of two independent groups to determine whether there is statistical evidence that the sample averages of the two groups are significantly different. For more details, data analysis can be seen in Table 2.

TABLE II
DATA ANALYSIS TECHNIQUE

Analysis	Formula
Descriptive Data	Percentage
Normality test	Kolmogorov Smirnov
Homogeneity Test	Levene Test
Hypothesis Test 1: There is a difference in the cognitive skills of the experimental class and control class students	Independent Sample T-test
Hypothesis Test 2: There is a difference in the practice skills of the experimental class and control class students	Mann Whitney

Virtual reality media in learning metal welding technology is designed using the C + programming system. The selection of this program is under the needs of media development in learning [17]. C+ is integrated with the Oculus virtual reality application that will be used in research. Students carry out the design of virtual reality media by paying attention to aspects of the similarity of the actual learning environment. The similarity of the virtual version with the real conditions is expected to provide students with the same knowledge and experience in implementing lectures [5].
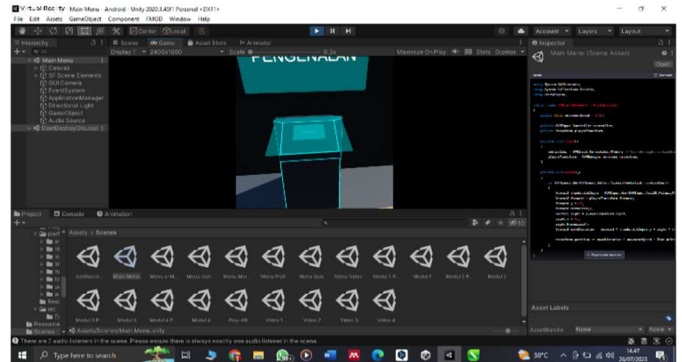

Fig. 2 Design coding for interactive media

VR-based learning media for welding technology courses were developed to support student understanding in learning. The main thing in this media is system functionality. This system is single-user or only accessed by one user. This application requires a VR device in the form of Oculus to operate it. The user's role is to control the course of the VR learning media application because there is no client-server interaction, commonly called stand-alone. In addition, in operating VR-based learning media with VR devices in the form of Oculus.
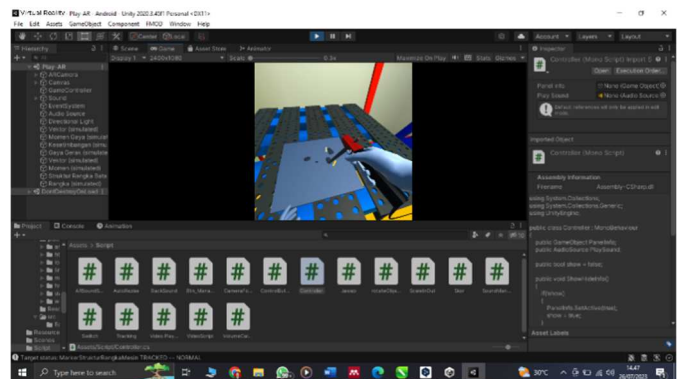

Fig. 3 VR media visual design

The design of the welding room in virtual form is adapted to the real form of the welding room in the mechanical engineering department, faculty of Engineering, Universitas Negeri Padang. These same visual aims to provide the same experience of the implementation of welding visually with hands-on practice at the Mechanical Engineering Department Fabrication workshop.
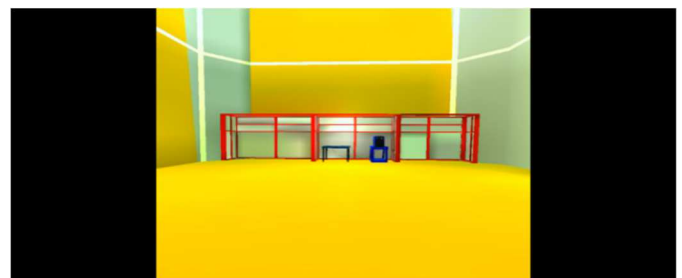

Fig. 4 Welding room design

In addition to the welding environment, other components that support welding activities are personal protective equipment and hand tools used to assist a welder in carrying out his duties. Students need to know the types of supporting equipment in the field of welding [18]. The use of equipment according to its function will guarantee personal safety when working and make the welder's job easier. These supporting components are also designed in virtual form to have the same dimensions and shape as the original size. Each indicator used can provide specific knowledge to students who use VR as a learning medium for welding practice. The following is a design form of the supporting equipment used in the virtual welding process.

A snapshot of the VR display from the welding laboratory is shown in Figure 4. Students can see the shape and layout of the laboratory, equipment with function descriptions, welding machines with settings, and can use welding machines virtually.
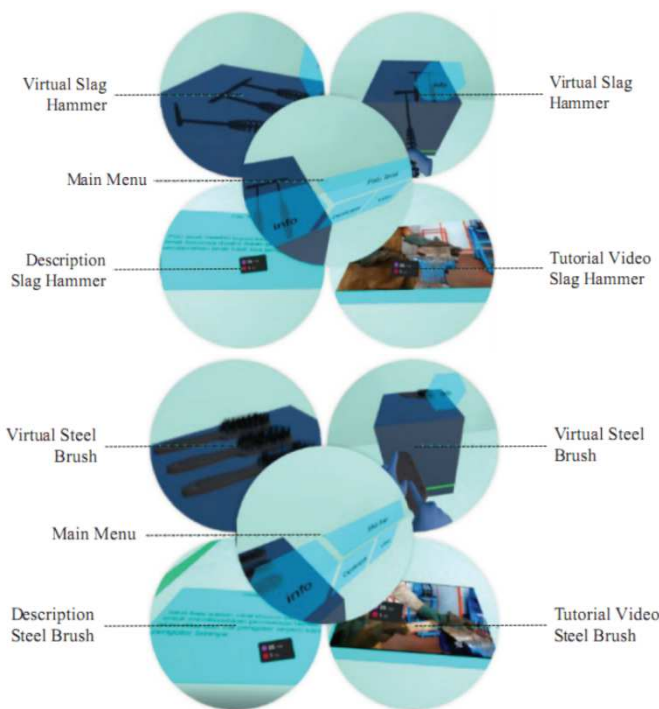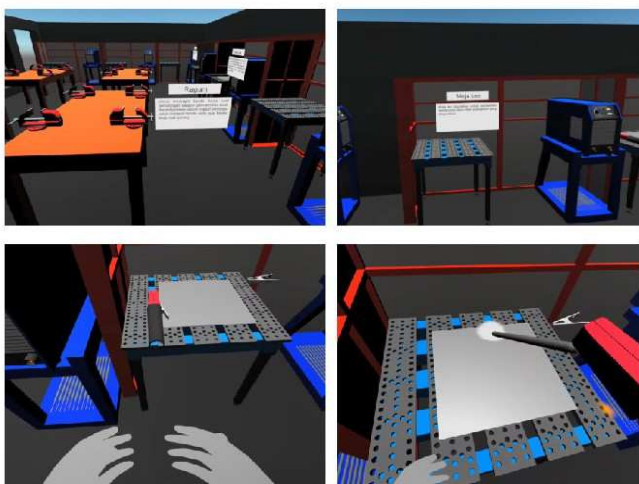

Fig. 5 Supporting equipment in virtual form

Fig. 6 VR Welding Practicum Display

III. RESULTS AND DISCUSSION

A. Results

1) Cognitive Skills: The results of the normality, homogeneous, and Mann-Whitney analysis of student cognitive skills assessment data are presented in Table 3. Based on the Kolmogorov-Smirnov test, the p-value for class A is 0.000, and class B is 0.003, which is smaller than 0.005. It means that the data is not normally distributed [19]. Based on the Levene statistic test, the p-value is 0.283. It is higher than 0.005. Thus, the data is homogeneous. Because the data obtained are not normally distributed, the hypothesis test used is non-parametric statistics, namely the Mann-Whitney test. Based on the Mann-Whitney test, the p-value is 0.000 and smaller than 0.005. It shows a significant difference in cognitive skills between class A, which uses slide shows and whiteboard learning media, and class B, which uses VR.

TABLE III
NORMALITY, HOMOGENEOUS AND MANN-WHITNEY TEST DATA FROM
STUDENTS' COGNITIVE SKILLS ASSESSMENT

Analysis requirements test	Class A	Class B
Normality	0.000	0.003
Homogeneous	0.283	
Mann-whitney	0.000	

2) Practice Skills: The results of the analysis of normality, homogeneous and independent sample t-test data from the assessment results of student practice skills are presented in Table 4. Based on the Kolmogorov-Smirnov test, the p-value for class A is 0.006, and class B is 0.010. This value is higher than 0.005. Therefore, the data are distributed normally [19]. Based on the Levene statistic test, the p-value is more than 0.005, which is 0.283. It means that the data is homogeneous. Because the data obtained are distributed normally and homogeneous, the hypothesis test used is parametric statistics, namely the independent sample t-test. Based on the independent sample t-test, the p-value is 0.598. It is greater than 0.005. Thus, there is no significant difference in practice skills between class A, which uses slide shows and whiteboard learning media, and class B, which uses VR.

TABLE IV
NORMALITY, HOMOGENEOUS, AND INDEPENDENT SAMPLE T-TEST DATA
FROM STUDENT PRACTICE SKILLS ASSESSMENT

Analysis requirements test	Class A	Class B
Normality	0.006	0.010
Homogeneous	0.363	
independent sample t-test	0.598	

VR media can provide experiences to students, even in virtual form. Memories stored when studying with VR media stay longer. Thus, when given a test, students can answer the questions better. Other research results also reveal that VR is useful for teaching concepts to students. There was no significant difference between classes A and B when testing students with direct practice skills on a welding machine. After analyzing the findings further, it is indicated that the developed VR media did not affect the psychomotor skills in the welding process. Several environmental factors affect the welding results in the welding process, including the heat of sparks, smoke, and lighting. VR technology has been unable to provide the feeling and view of the original environment. It can only be shown in the form of a display.

Welding practice requires subtle psychometrics, which can be formed through the intensity of practice. Welding work has several risk factors and conditions that will affect the quality of the results and the welding process. During welding, sparks, smoke, and light are problematic factors in getting good welding results. Welding operators often stop when welding because sparks hit the body, causing injuries. In addition, exposure to light and smoke during welding can cause eye irritation and pain. This condition certainly provides tension. Thus, a welding operator must have a strong mentality and be capable of controlling the risks in the welding process [20]. Psychomotor formation in the welding process must be carried out with continuous training. The use of VR media in research is still limited to understanding the concept.

B. Discussion

The foundations that need to be considered by educators in carrying out learning are philosophical, psychological, and practical foundations [21]. The foundation of philosophy itself, namely embracing aspects of philosophy that are very important in implementing integrated learning, is the main foundation that can underlie other aspects. Objectives and learning materials, in general, are often philosophically dependent. If different philosophical views can influence and encourage the implementation of teaching and learning that is not under the actual philosophical foundation [22].

The psychological foundation relates to the psychological development of students. Psychology can develop, but it must pay attention to the learning material that will be delivered to students. The aim is to increase the breadth and depth of the development of students [23]. Learning psychology can contribute to the material presented with the appropriate learning method or model. The basis of practice is related to real conditions, such as relating to events that have occurred in the environment around where students live; that way, students have no difficulty and are more familiar with the material presented by educators [24].

Nowadays, everyone is familiar with technology. They think of it like a computer. The word technology has many interpretations, and everyone calls it differently. Learning technology is the use and specific knowledge of tools so that they become skills in education and learning. Generally, people look from the perspective of educators. Most educators think that learning technology is a solution for all learning in the classroom. Almost all implementation of the curriculum uses technology [25].

Information technology will provide added value in the learning process. This relates to the increasing need for information on science and technology, not all of which are obtained in the school environment. Likewise, when exchanging data and information between schools, communities, local and central governments, etc., they will be more effective and efficient if they utilize information technology. The media that are deliberately designed for learning purposes are far more numerous than the media that are intentionally designed [26]. The media is found in our environment, does not need to be purchased, and is available by itself. For example, when educators explain the characteristics and types of wild or other animals, students can be taken to the zoo using field trips. If the educator will explain the types of rocks and fossils of ancient animals, students can be taken to the Museum of Geology (for students in the city of Bandung). For this, educators and schools must identify various potentials in their respective environments that can be utilized as learning media [27].

In recent years, with the development of mobile device technology, Augmented Reality and Virtual Reality have entered various fields. In the field of education, Augmented Reality and Virtual Reality have been widely used as research aids in laboratories and can also be used as learning media in classrooms. Augmented Reality and Virtual Reality technologies make it possible to incorporate virtual objects into the real environment and place appropriate information into the surrounding environment [28].

Virtual Reality or Virtual Reality is a technology that has made a big difference in human thought and is currently a trend to help improve performance and product quality [29]. VR or Virtual Reality is a technology created so that users can interact with an environment that a computer simulates. The development and use of learning media visually (images), audio, and video (multimedia) to the use of Virtual Reality and Augmented Reality in learning continues to be scrutinized and developed. This aims for effectiveness, efficiency, and motivation in student learning. VR is part of the multimedia computer, which will become a teaching trend in the future and is a new learning strategy in the engineering field to study a system [30].

The results of this study explain that the use of VR media for learning metal welding technology significantly positively influences the cognitive aspect. Students who were taught using VR media got higher scores compared to students who were taught with PowerPoint and blackboard media. The VR media used is able to provide experience to students even in virtual form. Memory absorption obtained by using VR media is more embedded in memory so that when given a test, students are more able to answer the questions given. These results are relevant to the cone of experience [31].
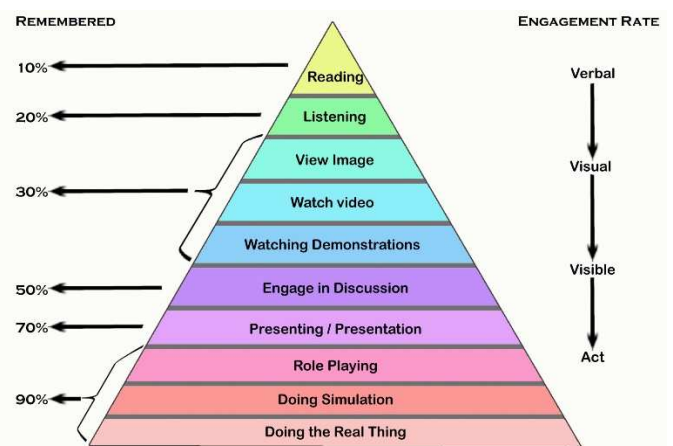

Fig. 7 Learning Experience Cone

In practical learning, student learning outcomes with VR media and classes with PowerPoint and whiteboard media did not significantly show different results. The results of these findings were further analyzed so that an indication was obtained that psychomotor skills in the welding process had not been obtained through the developed VR media. In the welding process, several environmental factors affect the welding results, including the heat of sparks, smoke, and

lighting. Psychomotor skills in welding are divided into two, namely gross psychomotor and fine psychomotor [32]. The formation of psychomotor skills should be based on the intensity of the exercise.

Learning Technology becomes a tool or tool in learning if students have difficulty solving problems during the learning process or do not understand the material that educators will deliver. The implementation of educator learning must consider many factors [33]. Basically, learning is the implementation of the applicable curriculum. Here, it definitely requires foundations and is based on the results of in-depth thinking. Learning generally occupies a very strategic position in educational activities [34]. With this important position, the learning process cannot be carried out haphazardly and must use a lot of strong or solid foundations. The foundation has the essence of the factors that need to be considered by educators when planning, implementing and achieving learning objectives which will later be the process of evaluating students.

Technological collaboration in educational elements will overcome existing problems in implementing education. Practical learning is often a big problem because it can hinder the transfer of competence to students [12]. Learning metal welding technology, which is practical learning and must be followed by all students majoring in mechanical engineering, requires students to carry out learning offline or face-to-face. The strategy used at this time is based on the policy of the university leadership in implementing practicum lectures carried out by reducing the capacity and intensity of students in learning. A possible solution in these conditions is the creation of an animated virtual learning container using VR tools. This tool will provide a real picture of the process and welding procedures that are the same as in the real world.

Media can be divided into two categories: learning aids (instructional aids) and learning media (instructional media). Learning aids or tools to assist educators in clarifying the material (message) to be conveyed [34]. Therefore, learning aids are also called teaching aids (teaching aids). Because the learning process is a communication process and takes place in a system, learning media occupies an important position as a component of the learning system. Without media, communication will not occur, and the learning process as a communication process will also not be able to take place optimally. Learning media is an integral component of the learning system but must be adjusted to the competency characteristics that become the output of learning.

IV. CONCLUSION

The results showed that VR in learning had positively impacted the cognitive sector but did not significantly contribute to the psychomotor sector. Learning using VR can increase student competence better than verbal involvement through visual images and videos. The existing VR technology could not provide conditions and sense following the real-life environment, only in three-dimensional vision. Therefore, the development of VR technology needs to provide better experiences and feelings closer to the actual environmental conditions.

Virtual Reality could make a difference, bring students to new knowledge, and motivate and trigger the students at every level of education. The following reasons to use virtual

Reality in education are: 1) it gives new forms and methods of visualization; Virtual reality display allows learners to observe visual objects that may not be able to do like in the real world; 2) it gives motivation to the students: Virtual reality system allow students to interact and work with other learners, which can encourage them to have interests in subject matter; 3) Can simulating a dangerous and/or expensive situations: virtual reality system allow learners to experience difficult tasks that hard/expensive to do in real-world; 4) Learning from an expert: Virtual reality system could allow the expert to share their experience to their students such as share their actions during doing a virtual surgery. Virtual reality system is a very useful technology that could improve education to the next level as we can see from numerous advanced virtual reality systems that use for training people, such as virtual neurosurgery simulation and virtual dentist simulation. In the future, virtual Reality will be widely used in numerous industries and fields.

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