Virtual Reality Laboratory for Chemistry Education: The Effect of VR-Lab Media on Student's Cognitive Outcome

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Abstract. The use of ICT is always developing in almost every aspect of life and led to the creation of new innovations based on ICT. Education is inseparable from the development of computer-based technology/ICT. Innovation in the education area can be done by making innovations in media learning. Virtual Reality Laboratory is an ICT-based simulation media, where students can doing a chemistry experiment virtually in the 3D environment. This study's aimed to investigate the effect of Virtual Reality Laboratory on student's cognitive outcomes in chemistry learning. This is a Research and Development (R&D) study that adapted the 4D Model by Thiagarajan. The research was conducted to ten-grade science students in High School. Students divided into two groups, one group as Control class and another as Experiment Class. Data on research was collected using a test. The result of the post-test was became the student's cognitive outcome score. The collected data hereafter was analysed using independent T-test. The conclusion was that VR Laboratory gives a positive effect on student's cognitive outcomes. Virtual Reality Laboratory can help teachers and students to improve student's cognitive outcomes in chemistry learning.

1. Introduction

Learning is a series of activities to obtain a change in behaviour as the result of the individual experience in the interactions with their environment [1]. The changes that occur include cognitive, affective, and psychomotor. Learning activities occur through the experiment [2]. In learning process, people do not only remembering something but also experiencing something. Learning experience have been gained by someone can reinforce individual behaviour changes. The learning process at educational institutions should be interactively, inspiringly, funny, challenging, and also motivating students to participate actively. Besides that, learning process also expected to provide sufficient space for initiative, creativity, and self-regulated in accordance with the talents, interests, and physical and psychological development of students [3].

Several internal and external factors can influence the success of learning process. Internal factors are factors that originate from within students, for example the health of students, student's mood, student's background, etc. External factors are factors that come from the student's environment, for example the learning media used in learning process, model of learning which used by teacher, school facilities, etc. The use of learning media serves to help the limitations of educators in delivering

material or help student's limitations in understanding learning material [4]. The other function of learning media are [5]:

a. Motivating students
b. Presenting some information to students about the material being studied
c. Giving instruction to students about what they have to do in learning process

In this era, there are many technology-based learning media have been developed. For example, there is ICT-based learning media is Virtual Laboratory. Virtual media in learning process are widely develop [6]. This learning media utilized technology to simulate chemistry experiment activity.

Chemistry as a science cannot be separate from the scientific approach. Scientific approach is a learning approach that consists of observing, questioning, experimenting, associating, and communicating [3]. Through the application of this approach in chemistry learning, students have been expected to be active learners, able to construct new knowledge or integrate it with previous knowledge through scientific stages. One of teaching method that is suitable with scientific approach is experimental method. Besides being able to train students' scientific skills, experimental activities also provide learning experiences to students directly. This activity can increase students' motivation, improve their skills, and help students to understand the material [7]. However, many schools minimize activities of chemistry experiment due to several limitations. Based on the results of observations, chemistry experiments in schools rarely carried-out due to limited time, chemical laboratories in schools that are inadequate for conducting experiments and limitations of tools and chemicals owned by schools.

Media of virtual chemistry laboratory can be used to overcome chemistry lab problems. This is chemistry laboratory based on virtual reality. Students or users can doing experiment virtually by using Virtual Reality Chemistry Laboratory media. This media provides a chemistry laboratory in a virtual environment, equipped with chemistry tools and chemicals in 3D. Virtual reality chemistry laboratory can be used as a solution to overcome some problems in conventional laboratories, for example, incomplete tools and chemicals, expensive experimental costs, inadequate laboratory facilities, experiments that take a long time [8]

The development of virtual chemistry as learning media rarely developed in Indonesia. However, this media has many benefits in learning activities. Therefore, in this study, researchers wanted to develop Virtual Reality Chemistry Laboratories that can use in chemistry learning. Chemistry material used in media development is Redox material. The developed media was tested in learning activity to find out how the effect of the media in the learning activity. The variable measured in a media testing was the students' cognitive outcome. Before used in the class, the validator tests the validity of the developed media to determine the appropriateness of the developed media.

2. Research methods

This was a research and development (R&D) that was adapted from a 4D developing model [9]. This model consists of 4 stages there are: Define, Design, Develop, and Disseminate. The product that was developed in this research is the Media of Virtual Reality Chemistry Laboratory.

2.1. Media Development

2.1.1. Define Stage.

This was the initial stage to determine and explain the materials needed in the learning activity. From this stage was obtained information such as:

1) Chemistry practical activity in the school was conducted rarely for several limitation reasons, such as limited time and improper laboratory facilities.
2) Participants are getting trouble to understand Redox material.
3) Redox material is one of chemistry materials that require experimental activities.

2.1.2. Design Stage.
In this stage was conducted development of learning media. The development of media was conducted using Blender and Unity application. The product of media that was developed is Chemistry Laboratory based on Virtual Reality arranged from 3D objects. Three dimension object inside of media consists of a chemistry laboratory room, practical table, whiteboard, teacher desk, cupboard, and chemistry tools and chemicals. These objects were arranged and set so that it can be operated virtually using an android smartphone. The result can be seen in the Figure 1 below. Inside the media consists of two practical table for two different experiment activities. The first is a Redox concept based on releasing and binding of oxygen was conducted in the left side. The second is the redox concept based on releasing and receiving of electron was conducted in the right side. The tools and materials needed to doing the experiment were available for each table.

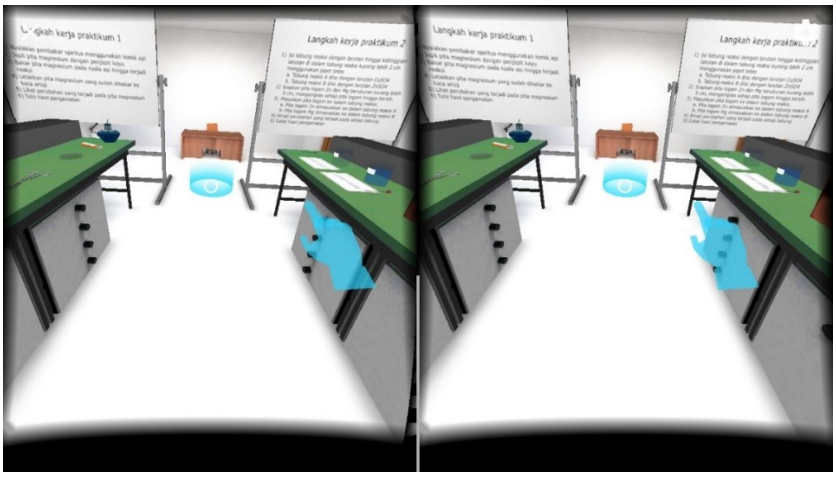

Figure 1. This is a figure of Virtual Reality Chemistry Laboratory appearance which developed by author.

2.1.3. Develop Stage.
In this stage, the developed media was tested and validated by experts. The test was conducted by the media expert, chemistry teacher, and high school students. The validation process was conducted by reviewing the product of media using media quality assessment form. The validation result have been obtained consists of a recommendation about the improvement virtual reality of chemistry laboratory media. Based on the validation result, can be concluded that the virtual reality of chemistry laboratory media can be used after revision in several parts.

2.1.4. Disseminate Stage.
The validated product of media then was spread to chemistry teachers and participants on a wider scale. One of the effective ways to spread the media by applying the media in the school to test the media effectiveness on a learning activity.

2.2. Subject of Research
The subject of this research consists of expert appraisal and developmental testing. The subject in expert appraisal consists of media experts, chemistry material experts, chemistry teachers, and ten-grade High School students. Developmental testing subject consist of ten-grade student of middle-up class in SMA N 7 Purworejo that divided into two groups. The first group was a Control class with 32 students and another was an Experimental class with 35 students.

2.3. Design of Developmental Testing Stage

The developed media was applied to learning activity in the school. Media application was conducted using a quasi-experiment method with post-test only design. The class that used in this research divided into two groups, there are control and experimental class. Post-test only design in this learning process can be seen in Table 1.

Table 1. Desain Post-test Only

Class	Treatment	Test
Control class	Experiments activities in real chemistry laboratory	Post-test
Experiment class	Experiments activities using Virtual Reality Chemistry Laboratory	Post-test

2.4. Data Collecting Technique

Data in this research was collected using test techniques. At the end of the learning activity, the researcher given an instrument test about the Redox question to the students. This instrument was used to test the students' understanding of the Redox material that has been taught. The test consists of 25 multiple choice questions with 5 optional answers and 5 essay questions. Experts have been validated the instrument test that used empirically and theoretically.

2.5. Data Analysis

The data that was obtained is quantitative data, which is the student's cognitive outcome score. The average score of control and experimental class shown in Table 2.

Table 2. The Average of Student's Cognitive Outcomes in Control and Experiment Class

Class	N	Mean	Standard Deviation
Experiment Class	35	74.97	14.46
Control Class	32	63.00	14.31

These data were analysed using the Independent T-Test statistical test to analyse the research hypothesis. Hypothesis in this research were:

H_0: There was no differences between the score of student's cognitive outcome in control and experimental class.

H_a: There was differences between the score of student's cognitive outcome in control and experimental class.

Rejection or acceptance of H_0 was based on the interpretation value of statistical test results (α). If the result below 0. 05 then H_0 was rejected and H_a was accepted.

3. Result

Before conducting a statistical test, data must be conducted Homogeneity and Normality Test.

3.1 Normality Test

The normality test was conducted to know is the data come from populations that were normally distributed or not. This test was required to test the result data of student's cognitive learning. This test was conducted using Kolmogorov-Smirnov test and SPSS 23. The analysis result was shown in Table 3.

Table 3. The Result of Normality Test

Class	Sig. Value	Conclusion
Experiment class	0.200	normal distribution
Control class	0.083	normal distribution

Based on the analysis result, it was obtained signification value for control class higher than experimental class 0.05, which means it can be concluded the data were normally distributed.

3.2 Homogeneity Test

Homogeneity test was conducted to know is the data come from a homogenous population or not. This test was conducted using the Levene test and SPSS 23. The result of the test is shown in Table 4.

Table 4. The Result of Homogeneity Test

Test	Sig. Value	Conclusion
Levene	0.764	homogeneous population

Significant value that was obtained in the homogeneity test is above 0.05, which means it can be concluded the data comes from the homogenous population.

3.3 The Result of the Independence T-Test

The test of Independence T-Test was conducted using SPSS 23 program. The result of the test was shown in Table 5.

Table 5. The Result of Independent T-Test

T	Sig. Value (2-tailed)	Mean Difference
3.404	0.001	11.971

Based on the table it was obtained the signification value is 0. 001 ($p < 0.05$), which means it can be concluded that H_o was rejected and H_a was accepted. In other words, there was a different result of student's cognitive outcomes between control and experimental class. To answer the hypothesis besides comparing the signification value can be conducted also comparing the T-test and T-table value. The value of T-table in the degree of freedom (dF) 65 with alpha (α) 0.05 was 1.997 while the value of the T-test was 3. 404. Since the value of the T-test was higher that T-table which means it could be concluded if the result of student's cognitive outcomes was significantly different between control and experimental class. The value of mean-different was positive, which mean the experimental class have a higher cognitive learning score than the control class.

4. Discussion

The product of developed media Virtual Reality Chemistry Laboratory was expected can be used as one of alternative chemistry learning media especially for a practical basis. Developed media consist of a file with an android package *.apk* format. The media of the virtual reality chemistry laboratory contain simulation of chemistry experiments in Redox material. The operational media was conducted using an android smartphone together with oculus and controller. This media can be used as a substitution or a supplement at practical activity in the chemistry laboratory. When the user use the media for doing experiment, they will feel like doing experiment in the real laboratory since the media was developed by Virtual Reality basis. All objects in the media were 3D also the environment was made as appropriate as a real chemistry laboratory. Users can explore the environment in the media freely.

The result of the validation shows media that be developed is feasible to use in chemistry learning activity. Then media is used to measure the result of students learning. The research process using two classes there are control and experiment class. Experiment class is a class that was conducting a practical using Media Virtual Chemistry Laboratory while the control class was conducting a practical in the real chemistry laboratory. The result of the analysis shows that the result of student learning in the experiment class is higher than in the control class. The application of technology in the learning process gave a positive effect on the result of student learning [10] [11] [12]. Virtual chemistry

laboratory applications were as effective as the real laboratory seen from learning outcomes and the ability of students to recognize laboratory tools [13]

The result of the observation especially at the Define stage shows that chemistry experiment was rarely conducted for several limitation reasons such as no time and improper laboratory facility. The developed Virtual laboratory can be used as a solution to resolve those problems. The virtual reality chemistry laboratory was developed and adjusted with the condition in the real chemistry laboratory also was completed with tools, materials, and facilities needed for experiment activity. Furthermore, to operate the media can be done anywhere and anytime, don't have to do when learning activity only. Therefore we can say that media virtual reality chemistry Laboratory can resolve several problems in the field. Virtual laboratory can resolve several problems in a conventional laboratory [8].

5. Conclusion

Based on the validation result, the media virtual reality chemistry laboratory that have been developed by the researcher could be used as one of the alternative chemistry learning media in the school. With this media, students could conducted chemistry experiment anywhere and anytime. In this research, the media result of development was used to measure the student's cognitive outcomes. Based on the statistical test could be concluded that students from the class were applying virtual reality chemistry Laboratory have cognitive outcome result higher than students from the control class that were not applying the media. This matter because students from the experiment class can repeat practical activity freely so they can understand the material better. Virtual reality chemistry laboratory can help teachers and students to improve student's cognitive outcomes in chemistry learning

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