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1 Virtual Laboratory to Improve Students' Conceptual Understanding in Physics Learning

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Abstract. Students' conceptual understanding is the main outcome of all education in the world. Students must be able to understand the concept well in order to apply their knowledge in daily life. One of the efforts to improve the conceptual understanding is through computer-based learning. This study aims to improve the students' conceptual understanding of physics by using the virtual laboratory. The participants of this study were students from three different senior high schools. The students were divided into three experimental groups and three control groups. The research instrument used was multiple choice forms. The results indicated that the use of virtual laboratory gave a positive effect on students' conceptual understanding. The final test result showed that the experimental group got a higher score than the control group. Data analysis was based on the number of students' correct answers in every cognitive aspect. The result of the analysis in every cognitive aspect showed that in each school, students were able to answer the questions correctly on aspects of C1 (remembering), C2 (knowing), C3 (applying), and C4 (analyzing). While on the aspects of C5 (evaluating) and C6 (creating) still needed to be improved.

1. Introduction

Physics is one of the subjects in school taking an important role in shaping the mindset of students to become a qualified human. That goal will be achieved if students can understand the concept of physics well and correctly, then applying the concept in everyday life. Hence in physics, students are trained to think in order to study a phenomenon logically and mathematically. Therefore, students are expected to have a good conceptual understanding so the goals of physics learning can be achieved as well.

Student's conceptual understanding is reflected in the results of physics learning evaluation. Silaban [1] argued that conceptual understanding is the students' ability in recording and back transferring of some information from learning, which can be used in solving, analyzing, and interpreting the problem. Many studies reveal that conceptual understanding is one of success learning indicator. Teachers as educators who have a direct role in student learning evaluation often complain about the achievement of students' physics learning results. Many students have not gained optimal learning outcomes and have not improved significantly. In this case, the quality and quantity of physics learning results are certainly influenced by many factors, one of them is the innovation in

learning, especially the use of the excellent learning media. Teachers as facilitators must be able to present the appropriate learning media to facilitate them to visualize abstract physics concepts [2].

Innovations in learning to support students' understanding are essential for educators [3]. One of the innovations that can solve the problem of student's conceptual understanding is the utilization of computer-based media. According to Tüysüz [4], the computer-based media use in laboratory activities can increase student's interest in learning in the classroom and also help them to improve learning outcomes. Laboratory activities are essential in physics learning. Through experimental activities, students' openness attitude and curiosity can be improved [5], and also practice their scientific attitudes. Jufri et al. [6] stated that the activities of physics experiments that are not supported by good facilities and infrastructure could have a negative impact on student learning outcomes. Therefore, computer-based experimental activities through virtual laboratories can be selected to visualize the physics concepts in order to make students understand the subject easily.

Many activities can be shown in a virtual laboratory, which covers presenting the practices and exercises, tutorials, games, simulations, inventions, and troubleshooting. This virtual laboratory provides an opportunity to use computer animation in learning that is oriented to microscopic representations. Students can experiment over and over again and also visualize the abstract processes that are impossible to see or imagine in a real laboratory. Some studies generally suggest that the use of virtual laboratories has a good impact on learning outcomes. Gunawan & Setiawan [7] found that the use of virtual laboratories can enhance conceptual understanding in modern physics courses, especially on the quantum theory of electromagnetic radiation and matter, which are abstract concepts that are difficult to visualize in real experiments. In addition, Nisrina et al. [8] also reveal that the cooperative learning models combined with virtual media can improve students' conceptual understanding in each sub-material of static fluid.

Based on the description that has been stated, this study uses the virtual laboratory media as an alternative to improve students' conceptual understanding. Virtual laboratories are used to help students in carrying out the experimental activities as well as in real laboratories. This study aims to improve students' physics concept understanding through the virtual laboratories. Students' conceptual understanding of physics in this study covers all aspects of cognitive according to Bloom's taxonomic revision by Krathwohl [9], which include remembering, understanding, applying, analyzing, evaluating, and creating.

2. Method

This quasi-experimental research with pre-test and post-test control group design was conducted at three different schools. The sample was chosen by purposive sampling technique, with total 195 samples that spread in three experimental groups and three control groups. The experimental group was given a learning treatment with the use of virtual laboratory media, while the control group was given the conventional learning treatment. The virtual laboratory consists of several computer simulations used for physics experiments. Learning in each session has been carried out for 90 minutes. Each student learns to use a virtual laboratory for 5 to 6 times.

Furthermore, the level of conceptual understanding of students was compared to each sample school. Student conceptual data are gained from multiple choice test instruments that have been tested for validity, reliability, differentiation, and difficulty. The test instrument included six cognitive aspects, namely C1 (remembering), C2 (understanding), C3 (applying), C4 (analyzing), C5 (evaluating), and C6 (creating). The conceptual understanding comparison of experimental groups and control groups in each school was performed with a simple analysis of the students' conceptual understanding test results and the number of students' correct answers on every cognitive aspect.

3. Results and Discussion

Conceptual understanding can be interpreted as an understanding of the concepts and the application in daily life. Conceptual understanding is not only about understanding simple concepts but also can be described as the ability to know, understand, apply, classify, generalize, synthesize, and conclude

the information obtained [10]. In this study, the virtual laboratory is used to improve conceptual understanding of physics concepts conducted at three different schools. The result of this study showed that there were differences in conceptual understanding in three schools. Figure 1 shows the comparison of the students' conceptual understanding.

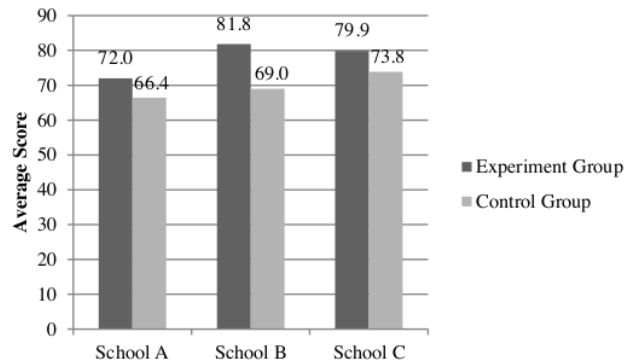


Figure 1. Comparison of students' conceptual understanding in each school

Figure 1 shows that in each school, the experimental group students have a higher score of a mean conceptual test than the control group students. At school A, the experimental group gets a higher score of 5.6% than the control group. While in school B, the experimental group gets a higher score of about 12.8% than the control group. Moreover, at school C, the experimental group get a higher score of about 6.1% than the control group. These results indicate that students' conceptual understanding of using virtual laboratories was better than conventional learning models. The findings of this study are supported by Gunawan et al. [11] who stated the virtual laboratories improve the students' conceptual understanding, both for males and females.

Virtual laboratories help students to develop physics and logic inference [12], enhance verbal and figural creativity [13], [14] and improve the ability to solve physics problems [15]. Wiyono et al. [16] state that the use of interactive multimedia can improve the physics conceptual understanding, especially abstract concepts. Interactive multimedia can help students to understand abstract physics concepts that are difficult to explain by the teacher. Furthermore, Zacharia & Anderson [17] revealed that the use of virtual media could help students visualized problems and solutions, and also can foster positive attitudes toward physics. Surely it is indirectly a positive impact on students' conceptual understanding of physics concepts.

The results of students' conceptual understanding tests were also analyzed based on the number of students' correct answers in each cognitive aspect. It is intended to know the level of conceptual understanding of the students obtained. Figure 2 shows the percentage comparison of the number of students' correct answers in every cognitive aspect. In each aspect, the experimental group also get a higher percentage than the control group, that are C1 (remembering) by 11.1%, C2 (understanding) by 1.1%, C3 (applying) difference by 7.7%, C4 (analyzing) by difference of 14.4%, C5 (evaluate) by 7.4% difference, and C6 (creating) by 2.7% difference. This result implied that the use of virtual laboratories in learning was able to provide better conceptual understanding in every cognitive level of students compared to the use of conventional learning models.

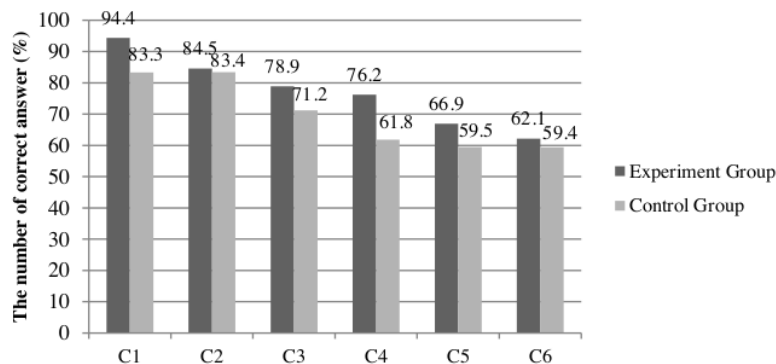


Figure 2. Comparison of the number of students' correct answers in every cognitive aspect

The percentage of the correct answers that the students successfully worked was on the cognitive aspect C1, that is by acquiring 94.4% for the experimental group and 83.3% for the control group. This result suggested that most experimental group and control group students can answer the questions in the remembering category correctly. The questions for category remembering were still relatively easy cause this was the lowest category. Problems with the remembering category did not involve a high-level thinking process. It just recognized or recalled a term, title, and formula without any claimed to understand or use it. In the C1 aspect, students just needed to take a simple knowledge of their memory. Therefore, it should be that the questions in this category can be answered well and correctly by the students.

Furthermore, for the questions in C2 (understanding) and C3 (applying) categories, most students in the experimental group as well as the students in the control group were still able to respond appropriately. Cognitive aspects of C2 and C3 were still relatively easy. Cognitive aspects C2 is the ability of a person to understand something, once something was known and remembered, and can see it in various ways. Understanding is a higher level of thinking ability than remembering. In the C2 aspect, students are required to determine the meaning of teaching messages, including verbal, written, and graphical communications. In the aspect of the C3 category, students are required to use procedures that are understood before in certain situations. The cognitive aspect of C3 is a higher level aspect of understanding (C2) because students must be able to collect and select appropriately a particular concept, law, proposition, rule, idea, or method known and understood in order to be applied to a new situation.

The percentage of students' correct answers on the cognitive aspects of C4 (analyzing) and forward begins to fall from previous cognitive aspects. In the cognitive aspects of C4, the experimental group get the correct answers percentage of 76.2% and 61.8% for control group. Nevertheless, this percentage is still quite good because more than half students can answer the C4 cognitive aspects correctly. The cognitive aspects of C4 and next belong to a high cognitive aspect. Students need to start using their high order thinking skills. In the analyzing aspect, students are required to break down the information that has been understood before into their constituent parts and to detect how the parts are interconnected with each other.

In the C5 (evaluating) and C6 (creating) questions, the percentage of students' correct answers decreases to below 70% and 60%. This is clearly due to the high-level thinking ability of C5 and C6 aspects. In C5 aspect, students are required to make a consideration of particular situations, values, ideas, or methods based on existing criteria and standards. The cognitive processes in this category involve interpreting, considering, examining, deciding, arguing, and criticizing. While in C6 (creating), students are required to create and combine several elements into a unified form. This C6 cognitive aspect creates some elements together to build a wholly logical and functional and organizes

them into new patterns or structures. Therefore, it is necessary to have excellent high-level thinking skills in order to understand the cognitive aspects of C5 (evaluating) and C6 (creating).

Analysis of students' answers on each aspect of cognitive showed that students' ability in answering conceptual understanding test was higher in the lower cognitive aspects, and otherwise was getting weaker on higher cognitive aspects. In this study, students' conceptual understanding of the cognitive aspects of C1 (remembering) to C6 (creating) overall was good. This was indicated by the percentage of students' correct answers on every cognitive aspect got more than 50%, with the percentage of the experimental group that was higher than the control group. This mean, more than half the students in the experimental group as well as the control groups had a good conceptual understanding. The use of virtual laboratories in experimen² group learning increased students' motivation to learn so they had better conceptual understanding than the control group. The findings of this study are in line with the findings of Gunawan et al. [11] study which reveals that the more interesting the learning media used, the more students' learning motivation. Thus, students' physics conceptual understanding is improved as well. By having a conceptual understanding, students can solve their problems during the learning process. Zacharia [18] stated that the use of virtual experiments ² could improve students' conceptual understanding compared to real experiments in the laboratory. The use of virtual laboratory can remove the tedious part of the real experimental activities [19]. It can help students understand the higher levels of cognitive analysis, synthesis, and evaluation ²

Based on the descriptions that have been put forward can be concluded that the use of virtual laboratory is very suitable for learning cause it can help students improve their conceptual understanding. Some studies have found that not all models or learning media can improve the conceptual understanding in all cognitive aspects. Rais & Ardhana [20] found that the application of project-based learning model is appropriate for teaching material in the higher cognitive domain such as application, analysis, synthesis, and evaluation. Conversely, the model is less appropriate to use in teaching lower cognitive domain. In addition to conceptual learning, it is also important to consider the good interaction between teacher and student and between student and student. Students' conceptual understanding will develop well if the good interactions occur during learning. The better the interaction that occurs, the better the conceptual understanding of the students.

² 4. Conclusion

Based on the result analysis and discussion; it can be concluded that the virtual laboratory gave the positive effect on student conceptual understanding. In each school, the experimental group students had the higher average score of conceptual understanding tests than the control group students. The result of conceptual understanding analysis on each cognitive aspect also showed that the experimental group students were better in answering the questions correctly than the control group students. The percentage of students' correct answers was highest on the C1 (remembering²) and the lowest on C6 (creating). Students were able to answer questions with cognitive aspects of C1 (remembering), C2 (understanding), and C3 (applying), and C4 (analyzing); while the cognitive aspects of C5 (evaluating) and C6 (creating) still needed to be improved again. As for suggestions for further research that is to combine virtual laboratory media with the approach or other learning strategies in order to obtain maximum results.

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