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The Effectiveness of Learning Using Virtual Laboratory Toward Student Critical Thinking Ability on Acid-Base Titration Lesson

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A B S T R A C T

The learning with experiment activities in the laboratory could increase students' critical thinking ability, but there were some obstacles in its implementation such as a lack of practical work tools in the laboratory. To overcome it, it was used a learning media that could show practical work virtually. This research aimed to know the difference in critical thinking ability between students taught by using a learning method with virtual laboratory and those who were taught by using conventional learning, and the effectiveness of learning using virtual laboratory toward student critical thinking. The experimental method was used in this research with pretest-posttest non-equivalent control group design and purposive sampling technique. The techniques of analyzing the data were t-test to know the difference in student critical thinking and N-gain test to know the effectiveness level. The research findings showed that there was a difference in critical thinking ability between students of experimental and control groups, the posttest mean score of critical thinking ability of the experimental group was 81.91 and the control group was 75.22, this difference could also be seen from the calculation result of t-test that the significance score 0.002 was lower than 0.05, so H_0 was rejected and H_a was accepted; effective learning. It was proven by the obtained N-gain score of each student in the experimental group, 28 students were in the high N-gain category with 93.33% percentage and 2 students who were in the medium N-gain category with 6.67% percentage.

Keyword : Effectiveness, virtual laboratory, critical thinking, acid-base titration.

I N F O A R T I K E L

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INTRODUCTION

Chemistry is a science that cannot be separated from chemical experimentation itself, and chemists cannot be separated from their mastery of concepts and skills in conducting experiments (Kurniawati and Fatisa, 2016). Therefore, chemistry is provided to students at the high school level to provide provisions in the field of experimentation. This is because, in addition to students having to know the basic concepts and supporting theories, they also need to carry out experiments or trials in the laboratory to understand certain concepts or basic theories that have been studied to have a broader level of understanding (Jaya, 2016).

Experiments can be done by carrying out practicum activities in the school laboratory. The implementation of experiments in the laboratory is the most important part of learning chemistry because it allows students to build experiences with concrete material. The laboratory is very important for making abstract chemical concepts concrete and making chemical materials easier to understand by students. One chemical material whose characteristics do not only require an understanding of the concept is acid-base titration. Learning on acid-base titration material also requires experimental or experimental activities in the laboratory. The laboratory is a place to do experimental activities, besides that the laboratory is also one of the methods in learning that serves to improve basic scientific facts in the laboratory environment. Activities in the laboratory can train and complement several student skills such as observing, classifying, measuring, communicating, interpreting data and making conclusions (Gunawan, 2017). One of the skills that can be trained through laboratory activities is critical thinking skills.

Students' critical thinking skills can be developed through learning chemistry in schools using appropriate learning methods. The learning method by conducting experiments in this laboratory can improve students' critical thinking skills and creativity because they can understand the material well (Juwariyah, et al, 2017). Critical and creative thinking are two types of thinking that sometimes cannot be separated from each other (Kadayifci, et al, 2012). Critical thinking skills are part of analytical skills or higher-order thinking skills (Suardana, et al, 2018). Based on the explanation above, therefore experimental activities in the laboratory are very important to do to support students' critical thinking skills.

Although laboratory activities are very important, in their implementation there are still various obstacles such as preparation and implementation of practicum requiring a long time, students are usually busy when carrying out practicum activities in the laboratory so that teachers have difficulty controlling, and limited tools limit the implementation of practicum activities (Khaeruman, et al. 2017). The use of virtual simulations may provide solutions to various problems that occur when carrying out practicum in the laboratory. The virtual laboratory is a computer-based media that contains simulations of activities in a chemical laboratory. The use of laboratory media at the teaching orientation stage will greatly help the effectiveness of the learning process at that time. Laboratory media can generate motivation, student interest, increase understanding, interpretation of data and information (Sawitri, et al., 2015). Also, virtual laboratories can improve critical thinking skills (Sutarno, et al, 2018). Virtual laboratories are created to describe reactions that may not be visible in real life. The advantage of using a virtual laboratory is that students can collect data quickly in any situation, besides that students can also carry out experiments safely if the actual experiment is dangerous. The use of virtual laboratories is also cheaper when compared to experiments in real laboratories that require relatively expensive equipment and materials (Totiona, et al, 2012). Virtual laboratories are created using software

technology. Virtual laboratories can be divided into two main types, namely laboratories based on simulators and laboratories based on real hardware equipment, both 2-D and 3-D (Jaya, 2012). Virtual laboratories that have been designed have not been tested for their effectiveness. Therefore, in this study, the authors are interested in testing the effectiveness of a virtual laboratory that has been designed to support students' reflective thinking abilities. The virtual laboratory that has been created to support this ability of reflective thinking, contains a gap to support critical thinking skills in it. To see the extent to which the virtual laboratory is effective against students' critical thinking skills, its effectiveness is tested. Virtual laboratories that have been designed have not been tested for their effectiveness. Therefore, in this study, the authors are interested in testing the effectiveness of a virtual laboratory that has been designed to support students' reflective thinking abilities. The virtual laboratory that has been created to support this ability of reflective thinking, contains a gap to support critical thinking skills in it. To see the extent to which the virtual laboratory is effective against students' critical thinking skills, its effectiveness is tested. Virtual laboratories that have been designed have not been tested for their effectiveness. Therefore, in this study, the authors are interested in testing the effectiveness of a virtual laboratory that has been designed to support students' reflective thinking abilities. The virtual laboratory that has been created to support this ability of reflective thinking, contains a gap to support critical thinking skills in it. To see the extent to which the virtual laboratory is effective against students' critical thinking skills, its effectiveness is tested. The virtual laboratory that has been created to support this ability of reflective thinking, contains a gap to support critical thinking skills in it. To see the extent to which the virtual laboratory is effective against students' critical thinking skills, its effectiveness is tested. The virtual laboratory that has been created to support this ability of reflective thinking, contains a gap to support critical thinking skills in it. To see the extent to which the virtual laboratory is effective against students' critical thinking skills, its effectiveness is tested.

RESEARCH METHODS

The research was conducted by experimental method, in which researchers investigate the effect of a treatment on research subjects (Kurniawati, 2019). This type of research is quasi-experimental research. Quasi-experimental research in which research is carried out using all subjects in the study group to be treated and not using randomly drawn subjects. The form of the Quasi-Experiment used is the Non-Equivalent Control Group Design.

The selection of this design is intended to see the initial state, namely whether there is a difference before the treatment is given between the experimental group and the control group. The experimental class is a class that is treated using virtual laboratory learning media and the control class does not use learning media. Before being given treatment, both classes were given a pretest, after treatment was given a posttest. The questions used in the pretest and posttest are the same with the same processing time. The results are compared (Sukardi, 2009) and it is seen that the more effective the students' critical thinking skills increase is higher.

Data collection techniques used include tests (the test method consists of evaluation questions consisting of pretest and posttest), unstructured interviews, and documentation. Based on the data obtained from the results of the essay test analysis, the scores are then interpreted in the form of categories to make it easier to read and easier to conclude that each critical thinking ability is included in the category of very good, good, sufficient, less or very lacking.

The data analysis technique to test the hypothesis used in this study was the "t" test. A T-test is done because the type of data in this study is in the form of intervals. Meanwhile, to see the category of effectiveness, the N-Gain calculation was used which is obtained from the pretest and

posttest scores of each experimental class and control class. (Riduwan, 2009).

RESULTS AND DISCUSSION

Learning activities using virtual laboratories to support students' critical thinking skills on acid-base titration material were only carried out in the experimental class, while the control class was used as a comparison class without being given the same treatment. This is done to see whether the virtual laboratory is effective against learning or not.

Based on the results of the hypothesis testing conducted, it can be observed that there are significant differences between the experimental class and the control class. That is, learning using a virtual laboratory is effective in supporting students' critical thinking skills on acid-base titration material. There are five indicators of students' critical thinking skills measured in this study, namely providing simple explanations, building basic skills, making conclusions, making further explanations, arranging strategies and tactics. The percentage of achievement of each indicator of critical thinking skills can be seen in Figure 1 below.

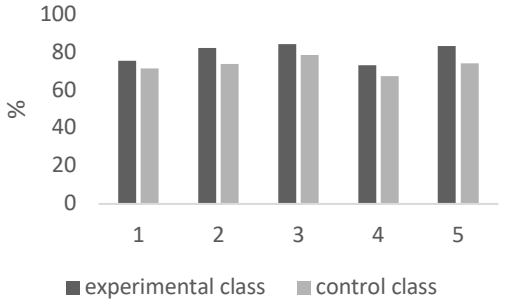

Figure 1. Percentage of Critical Thinking Ability Indicator Achievement

The first indicator measured in this study is to provide a simple explanation. The data above shows that the percentage of achievement of the indicators provides a simple explanation for the experimental class of 75.83% which is included in the good criteria, while in the control class it is 71.66% which is included in the good criteria. The high percentage of achievement indicators provides a simple explanation for the experimental class due to the use of virtual laboratories in the experimental class. Virtual laboratories have the advantage of packaging learning more effectively and efficiently in one medium, being able to explain less tangible material using simulations, making it easier for students to provide simple explanations. This is supported by research (Bakti, EMS, et al. 2013) which explains that virtual laboratories have the advantage of being able to do learning effectively and efficiently so that students' critical thinking skills improve, one of which is the indicator providing a simple explanation.

The second indicator of critical thinking skills in this study is an indicator of building basic skills. The percentage of achievement indicators building basic skills in the experimental class is higher than in the control class. Based on the data, it can be seen that the percentage of achievement in the experimental class is 82.5% which is included in the very good criteria, and in the control class the percentage of achievement is 74.16% which is included in the good criteria. The achievement of the experimental class indicators was higher than the control class due to the characteristics of the acid-base indicator material which is an abstract material that can be explained in real terms using a virtual laboratory so that students can build basic skills. This is supported by research (Fonna, TM, et al, 2013) which states that abstract materials can be explained in real terms by virtual laboratories so that they can build the basic skills of students.

The third indicator of measured critical thinking skills is making conclusions. Based on the data, it can be seen that the percentage of achievement in the experimental class shows many 84.72% which is included in the very good category, while the control class has a percentage of achievement of the third indicator of 78.88% which is in the good category. This happens because the virtual laboratory can invite students to deduce and consider the results of the deduction, induce and consider the results of the induction, make and determine the results of the consideration. A study

(Simbolon, 2015) stated that virtual laboratories can improve students' ability to make inferences or conclusions.

The fourth indicator of measured critical thinking skills is an indicator of making further explanations. Skills in making further explanations require students to analyze and then synthesize further explanations related to the material. Virtual laboratories as media can display virtual lab work so that they can bridge learning to support students to be able to analyze and then synthesize (Permana, 2016). In this indicator, students can analyze or identify how the tools or materials are right and what will happen when practicum is done so that they can provide further explanation. This is supported by research which states that virtual laboratories can improve students' ability to provide further explanations (Najib, 2013). The posttest value data shows the percentage of achievement of the experimental class indicators is higher than the control class. The percentage of achievement in the experimental class shows several 73.33% which is included in the good category, while the control class has a percentage of 67.5% which is included in the good category. This is because the use of virtual laboratories can help improve students' critical thinking skills, one of which is in providing further explanations.

The fifth indicator of critical thinking skills in this study is to set strategy and tactics. Based on the data, it can be seen that there are differences in the achievement of the fifth indicator in the experimental class and the control class. This is due to the advantages of virtual laboratories which are more time-efficient, safer, cheaper, and easier to use as an alternative to practicum, making it easier for students to set strategies and tactics in learning. This is supported by research in research (Permana, 2016) which states that the conveniences provided by virtual laboratories help students in determining strategies and tactics in learning so that critical thinking skills increase. The posttest value data shows the percentage of indicator achievement in the experimental class is 83.74% which is included in the very good category, while the control class has a percentage of indicator achievement of 74.58% which is included in the good criteria. This percentage difference is caused by the experimental class using virtual laboratory media that can display simulations that make it easier for students to understand so that they can determine strategies and tactics in learning. The highest achievement of critical thinking ability indicators among the five indicators in the experimental class and control class is the third indicator with 84.72% and 78.88% respectively. The third indicator of measured critical thinking skills is making conclusions. This is because the virtual laboratory learning media can help students understand abstract material to be more real so that it can invite students to deduce and consider the results of deductions, induce and consider the results of induction, make and determine the results of considerations or make a conclusion. The results of the post-test data for the experimental class and the control class show that there is a difference in the average value of the control and experimental classes. The experimental class obtained an average value of 81.91 while in the control class the average posttest score was 75.22. From this difference, it can be concluded that learning using a virtual laboratory is effective for students' critical thinking skills on acid-base titration material compared to learning using conventional PPT-assisted methods that are applied.

Based on the N-Gain test that has been done and used to obtain the results of categorizing the effectiveness of learning using a virtual laboratory on students' critical thinking skills on acid-base titration material. The N-gain calculation is obtained from the pretest and posttest scores for each student. The results of the N-gain calculation for each experimental class student are presented in the table 3.

Table 3. Results of the N-gain calculation

N-gain	Category	Ex Class		Control Class	
		JS	%	JS	%
g > 0,7	Hight	28	93,33%	10	43.3%
0,3 ≤ g ≥ 0,7	Medium	2	6,67%	20	56,7%
g < 0,3	Low	0	0%	0	0%

Judging from the calculation of the N-gain test presented in the table above, it shows that the N-gain category obtained in the experimental class in the high category was 28 students with a percentage of 93.33% and there were only 2 students in the N-gain category. moderate with a percentage of 6.67%. This is included in the high category so that it can be said that the use of virtual laboratories is effective for students' critical thinking skills. Whereas in the control class, there were 13 students in the high category of N-gain achievement with a percentage of 43.3% and 17 students in the moderate category with a percentage of 56.7%, which means that learning is quite effective in the control class.

Based on the results of indirect interviews conducted with students with the sound of the questions asked "is the virtual laboratory media practical learning becoming more practical?". Most of the students responded by answering "yes" with a percentage of 75%. This shows that the virtual laboratory is a learning medium that can help students learn learning material through electronic media practicum activities in the form of a virtual laboratory. So that students have the ease of carrying out practicum activities. This is supported by research (Khamzawi, 2015) which states that the practicality and ease of using media can make it easier for students to understand the material presented in the media. Meanwhile, the interview question "Is virtual laboratory media very easy and beneficial when learning in class?". The result of the response from the students' answers to this question is the number of students who answered yes and no is the same as a percentage of 50%. This may be because the method used at the time of learning is the method of discussion. The discussion process with a one-group system consisting of five students resulted in the learning process of one laptop unit containing virtual laboratory media being used alternately by five students so that the virtual laboratory was not optimally used in learning activities. This is supported by the research cited in the study (Permana, 2016).

CONCLUSION

Based on the analysis of the data obtained, the following conclusions can be drawn There are differences in the results of critical thinking skills between the control class and the experimental class that was treated using a virtual laboratory assisted learning method and the control class using conventional methods. This difference can be seen from the average acquisition of the results of the posttest critical thinking ability of the experimental class is 81.99 and the control class is 75.22.

Learning using a virtual laboratory on students' critical thinking skills is effectively used in class X chemical engineering competency skills on acid-base titration subject at SMKN 2 Pekanbaru.

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