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The Impact Of Inquiry-based Virtual Laboratory On Students' Inquiring Abilities

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This study aimed to determine the ability of inquiring in the class using an inquiry-based virtual laboratory. The research design of this study was based on quasi-experimental research using the pre-test post-test non-equivalent control group design. The results showed that the inquiring abilities for the experimental class had increased as a result of the learning process. A significant value was obtained based on the t-test for the experimental class. In the control class, there was an increase in the process of asking questions, making hypotheses and conclusions and communicating. A significant difference was found in the inquiring abilities of students in the classroom using the inquiry-based virtual laboratories as compared to students who had not used the virtual laboratory.

Keywords: Inquiry Abilities, Inquiry-Based Virtual Laboratory, Virtual Laboratory Media

Introduction

In the era of globalization, information, media, technology skills, learning and innovation skills have become important in the 21st century. Technological developments can help teachers make it easier to carry out the learning process. Subject matter that is abstract or difficult to imagine, will be easier if visualized using media, especially technology-based media. The use of multimedia can positively influence the concepts being learned by the students

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as they can be visualized easily (Beydogan & Hayran, 2015). Extensive use of animation and chemical modelling using computers makes the learning process visual, understandable and easy to remember (Boboev, Soliev, & Asrorkulov, 2018). Computer programmes are often used as learning tools because computers can integrate sound and music with animated graphics (Astra, Nasbey, & Nugraha, 2015).

Students experience many difficulties in learning and understanding chemistry, one of which is because of views about chemistry that are academic and not related to everyday life (Treagust, Duit, & Nieswandt, 2016). One topic that is still considered difficult by students is chemical equilibrium (Özmen, 2008), because of its abstract character and a large number of demands for material mastery (Pardo & Portoles, 1995). Chemical learning is not only related to concepts and calculations that are delivered directly by the teacher but requires practicing. Practical activities are very important in studying chemistry. Theory and practice need to be integrated with one another. In chemical equilibrium course, there are theories about chemical reactions that require practice because the resulting reactions are related to distinctive colour changes (Leal & Leal, 2013).

We can do practical activities with the help of technology-based media. The existence of a virtual laboratory can facilitate teachers in conducting practical activities. Virtual laboratories are a series of laboratory tools and materials that are packaged in the form of software. Virtual laboratories provide simulated versions of a real laboratory for learning by representing virtually real objects used in laboratories (Faour & Ayoubi, 2018). Students can easily do practicum whenever and wherever. The advantage of using a virtual laboratory is that it does not endanger the user and the results obtained are the same and can be used continuously without limitations. In addition, the main advantage of virtual labs is the use when considering the existence of explosions and fire processes, reactions involving toxic substances and radioactive substances, and things that make it dangerous for students' health (Boboev, Soliev, & Asrorkulov, 2018). A virtual laboratory is one of the real lab alternatives that can be used to conduct experiments if you cannot do it in a real lab for several reasons (Tuysuz, 2010).

Combining media and learning models can help introduce new techniques in teaching. However, the teacher must choose the right media and model to integrate together. The media used in this study is inquiry-based virtual laboratory media that has been tested before and is considered worthy of use. In this media, there is a syntax of an inquiry model in conducting practical activities. The inquiry is a way to learn new skills and expand knowledge in understanding information. The learning process using the inquiry model involves students to think, ask questions, conduct exploration and experimental activities so that students are able to present ideas that are logical and scientific (Coffman, 2009).

Students who conduct investigations require reasoning skills in using laboratory equipment or in the learning process. According to the National Research Council (1996), knowing the inquiry abilities of students can provide information to teachers about how well students have met the standards of inquiry. So, the assessment of inquiry abilities is important to be done by the teacher in the learning process using the inquiry model. However, it is still rare to assess inquiry abilities in high school students in the chemistry learning process. Handayanti, Sopandi, and Kadarohman (2016) showed that so far previous studies have only examined inquiry and its relationship with improving students 'understanding of concepts but research has rarely been conducted which has attempted to map students' abilities in chemistry subjects. The information obtained about inquiry abilities is very important as it provides input regarding the material and evaluation of learning carried out by teachers in the classroom.

RESEARCH METHODOLOGY

Research was conducted using the quasi-experimental research methodology involving pre test–post test non-equivalent control group design. In this study, there were two classes namely the experimental class and the control class. The experimental class received treatment with learning using inquiry models with inquiry-based virtual laboratory media. Learning in the control class used the inquiry model with conventional laboratory work practices. This research was conducted for one month with a sample of 62 students in class XI IPA. The quasi-experimental research design has been given in Table 1.

Table 1

Pre Test–Post Test Non-Equivalent Control Group Design.

Class	Pre Test	Treatment	*Post Test*
Experimental	O_1	X_1, O_2	O_1
Control	O_1	X_2, O_2	O_1

Note: X1= learning using inquiry-based virtual laboratory media; X2= learning using conventional laboratory; O2= observation ability inquiry sheets; O1= inquiry abilities questionnaires

DATA COLLECTION

In this study, the instruments used for data collection were inquiry ability observation sheets, and inquiry ability questionnaires. All instruments used have been validated theoretically by expert judgment so that they are suitable for use. Observation was carried out during the learning process to see how the students' learning process uses the inquiry model. The inquiry ability observation sheet consists of 15 statements. Questionnaire for inquiry abilities is given before and after the learning process which consists of 20 statements with 5 alternative answers (Likert scale). The observation sheets and inquiry ability questionnaires were developed from the synthesis of inquiry stages which led to the emergence of the inquiry abilities of students according to Lou, Blanchard, and Kennedy (2018); Zulfiani and Herlanti (2018); Kambeyo (2017); Wenning (2007); Lukac (2015); Wu and Hsieh (2006); Mumba, Chabalengula and Wise (2007); and the National Research Council (1996). The inquiry syntax used to find out the student inquiry abilities can be seen in Table 2.

Table 2

The Inquiry Syntax Used to Find Out the Abilities of Student Inquiry.

The Inquiry Syntax	Description
Asking Question	The ability of students to ask questions related to the problem to be investigated
Making a Hypothesis	The ability to make hypotheses is based on the study of theory
Conduct Investigations	The ability to carry out investigations by designing investigations and conducting investigations systematically
Analyse and Describe	Analyse and describe the results of the investigation by relating it to the theory and checking the truth of the findings
Conclusion and Communication	Conclude the results of the investigation logically and relevantly, and communicate the results obtained briefly and clearly

LEARNING PROCESS

In the experimental and control classes there were 5 face-to-face meetings to discuss chemical equilibrium material. The two sample classes use the inquiry learning model, which distinguishes between the experimental and control classes when students do the practicum. The experimental class when doing the practicum uses inquiry-based virtual laboratory media. The control class does practicum as usual in the laborat*ory* using laboratory equipment and materials. Practical activities are carried out when discussing reversible and irreversible reactions, as well as factors that influence the shift in chemical equilibrium. Questionnaire for inquiry abilities is given before and after the learning process. Observation of inquiry abilities is carried out during the learning process.

RESULTS AND DISCUSSION

The data obtained through the inquiry abilities questionnaire was subjected to the test for normality and homogeneity. Normality test was used to find out that the data obtained was normally distributed or not. Homogeneity test was used to find out if the data obtained was taken from a homogeneous sample group or not. The results of the normality and homogeneity test can be seen in Table 3.

Table 3

The Results of the Normality and Homogeneity Test.

	Test	Class	Sig	
Normality	Pre test	Experimental	0.194	Normal
		Control	0.166	Normal
	Post test	Experimental	0.120	Normal
		Control	0.200	Normal
Homogeneity	Pre test	Experimental and Control	0.593	Homogeneous
	Post test	Experimental and Control	0.234	Homogeneous

The results of the analysis for normality and homogeneity tests can be said to be normal and homogeneous if the significance value is < 0.05. All data obtained after analysis shows that data is normally distributed and homogeneous.

Inquiry Ability

Student inquiry abilities can be assessed from the questionnaire data obtained from the experimental and control classes. In addition, there was an observation of inquiry abilities carried out during the learning process that can support data from the questionnaire obtained. The results of the questionnaire obtained in the experimental and control classes can be seen in Table 4.

Table 4

The Results of the Questionnaire Inquiry Abilities.

	Experimen t Class		Control Class	
	Before	After	Before	After
Highest score	90	96	85	90
Lowest score	61	60	62	60
Total score	2413	2535	2205	2234
Average score	75	79	73,5	74

Based on results given in Table 4, it can be seen that the inquiry ability score in the experimental class was higher than the control class. The highest score for the experimental class before learning was 90 and for the lowest score of 61 while after learning the highest score was 96 and the lowest score was 60. The questionnaire score for the control class, before the learning process was 85 and the lowest score was 62, while after learning the highest score was 90 and the lowest score obtained was 60. The average score before and after learning for the experimental and control classes has increased. There were 5 aspects that can be seen for the ability of inquiry from students, namely asking questions, writing hypotheses, conducting investigations, analyses and descriptions, as well as conclusions and communicating. The results of the assessment for each aspect in detail for the experimental class can be seen in Figure 1.

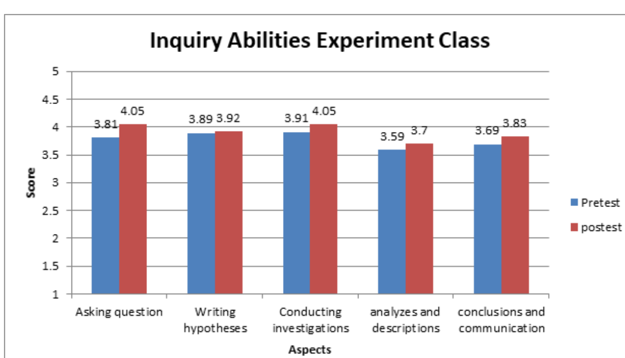

Figure 1. Assessment of Each Aspect of the Pre Test and Post Test of the Experimental Class.

Based on Figure 1, it can be seen that from the 5 aspects of inquiry, the highest score of the highest aspect for the experimental class was the aspect of asking questions. Each aspect experiences an increase in scores before and after the learning process. The aspect that has the highest increase was the aspect of asking questions. The lowest score of was on analysing and describing aspect.

Data on inquiry abilities obtained from questionnaires were similar to the results of observations in class and worksheets of students. Based on observation, students are better at making questions. Questions that are made are weightier and lead to the problem being investigated. At the beginning of the meeting, students only make 1-2 questions, but gradually they make more questions. The students are getting better in making hypotheses, although there is not much improvement from the beginning of the meeting. The learning resources they read to write hypotheses are increasingly diverse, so the answers are weightier. The aspect of conducting an investigation increases before and after the learning process. After students know that they must be able to find and understand the material themselves, they prepare more material before the learning process begins. Therefore, when students conduct an investigation, they are easier to design a practicum, do a practical, or answer related questions in finding the concept of chemical equilibrium material. This result is similar to the research conducted by Winkelman, Baloga, Marcinkowski, Giannoulis, Anquandah, and Cohen (2014), which shows that students actually improve their abilities in planning and understanding experiments. The aspect of analysing and describing has the lowest score compared to the other 4 aspects. Based on the results of student observations and answers from the worksheet, some students experienced confusion in analysing and describing the results of the data obtained based on the investigation. They still need a long time to analyse data by relating theory. Aspects of conclusions and communicating has also increased. Students have been able to draw conclusions correctly based on the problem they are investigating. In addition, students dare to present and explain the results of the investigation in front of the class with confidence.

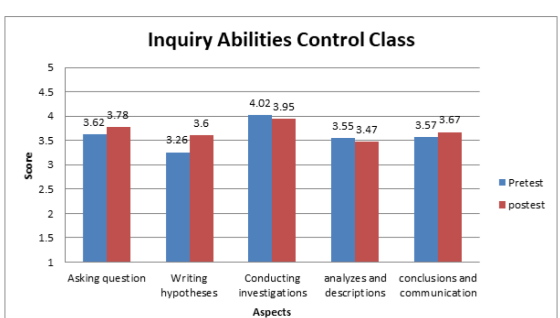

Figure 2. Assessment of Each Aspect of the Pre Test and Post Test of the Control Class.

The scores of the control class inquiry ability for comparison of each aspect can be seen in Figure 2. Based on the 5 aspects of inquiry, aspects that experienced an increase before and after the learning process were aspects of asking questions, making hypotheses, conclusions and communicating. The aspect of investigating, analysing and describing has decreased despite its small percentage. The aspect that has the highest score increase is making a hypothesis, even though among the 5 aspects of inquiry the aspect of asking questions has the lowest score. The aspect of investigating decreased before and after the learning process but had the highest score compared to the other aspects.

Based on the results of observation data, some control class students had difficulty in conducting investigations and in analysing and describing. They experienced difficulties when conducting investigations using inquiry learning models. Students found it difficult to analyse the problems being investigated. The teacher assisted students in conducting investigations regarding problems that were being investigated so that students understood better. Aspects of conclusions and communicating have also increased. Students can draw conclusions based on the goals they are working on. In addition, they have made effort to present and explain the results of learning in front of the class with confidence.

Differences in the Capability of Experimental Classes and Control Classes

In this study, to find out whether there were significant differences in the ability of inquiry students in experimental and control classes and whether there are significant differences in inquiry abilities before and after the learning process in the experimental and control classes a paired sample t-test was used. The results of the paired sample t-test can be seen in Table 5 and Table 6 and for Independent samples t-test in Table 7.

Table 5

Paired Samples Test for Experiment Class.

Paired Differences					*t*	df	Sig. (2-tailed)
Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
			Lower	Upper			
-3.81250	5.42656	0.95929	-5.76898	-1.85602	3.974	31	0.000

Table 6

Paired Samples Test for Control Class.

Paired Differences					*t*	df	Sig. (2 - tailed)
Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
			Lower	Upper			
-0.96667	5.14268	0.93892	-2.88697	0.95364	1.030	29	0.312

The paired sample t-test results for the experimental class can be seen in Table 5. The t value obtained is significant at 0.01 level and thus H0 is rejected which means there are significant differences before and after learning using inquiry-based virtual laboratories. This is in accordance with the average questionnaire scores before and after the learning process that have differences. Before the learning process in the experimental class the average score of inquiry ability was 75 while after the learning process it was 79.

Paired sample t-test for the control class is presented in Table 6. The t value is not significant and thus the H0 is accepted, which means there is no significant difference before and after learning in the class that does not use virtual laboratory media. The average score of the questionnaire before learning was 73.5 while after learning was 74. The average score of the questionnaire before and after the learning process was different but not significantly different, so the results of the analysis using paired sample t-test showed no significant difference before and after learning.

Table 7

The Results of Independent Sample t-Test.

F	*t*	df	Significance (2-tailed)
0.042	2.274	60	0.027

Based on the results of the analysis from the independent sample t-test as given in Table 7, it can be seen that the value of t is significant at 0.05 level and thus H0 is rejected which means that there is a significant difference in the ability of inquiry students in the experimental class as compared to the control class.

Practicum conducted using virtual laboratories has a positive influence on students' achievement and their attitude towards chemistry when compared to traditional teaching methods (Tüysüz, 2010). Harrison, Shallcross, Heslop, Eastman, and Baldwin (2009) conducted a study of the effect of virtual laboratories and the results showed that students using virtual chemistry lab software found it easier to answer questions related to practical techniques and they were also focused on conducting experiments and understanding more about experiments. do. In addition, Brinson (2015) also conducted a study that most of the studies reviewed showed that students' learning outcomes were the same or higher in the class using non-traditional (virtual and remote) laboratories compared to traditional laboratories viewed from all learning outcomes (knowledge and understanding, practical skills, inquiry skills, perception, analytical skills, and social and scientific communication).

Virtual laboratory applications in science learning can support students' understanding of subject matter, learning critical thinking and improving problem-solving (Chiapetta & Koballa, 2010). The use of virtual laboratory motivates students to repeat experiments that they do not understand, does not require expensive fees, does not dispose of any material and is safe (Tatli & Ayas, 2010). In addition, computers in science learning are appropriate and comfortable, especially when content is used well (Tuysuz, 2010).The use of inquiry-based virtual chemistry laboratories that have been carried out in this study can improve students' inquiry skills before and after the learning process. According to this diagnosis of students' abilities, certain learning environments can create student inquiry skills (Kambeyo, 2017). Inquiry learning, using media plays a role in improving students' thinking skills. This is because the inquiry approach is an approach that makes students learn actively in doing and thinking (Widowati, Nurohman & Setyowarno, 2017). Teachers must believe learning with the inquiry approach can stimulate student behaviour, not just transfer of knowledge (Herga, Cagran, & Dinevski, 2016).

CONCLUSIONS

Based on the research that has been done, it can be concluded that there is a significant difference in the ability of the inquiry classroom using inquiry-based virtual laboratories with students who do not use the media. Significant values were obtained based on the independent sample t-test. In the experimental class using paired sample t-test there were significant differences before and after the learning process. The aspect of inquiry ability for the experimental class had also increased before and after the learning process. In the control class, the results of the paired sample t-test show that there was significant difference before and after learning in the control class. Aspects that experienced an increase before and after the learning process were aspects of asking questions, making hypotheses, conclusions and communicating. The aspect of investigating, analysing and describing had decreased despite its small percentage.

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