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Effectiveness of the use of real and virtual laboratories of student learning outcomes based on student critical ability

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Abstract
The situation of teachers who do not know the individual circumstances of students, teachers who never measure the critical thinking skills of students resulting in low student learning outcomes in science subjects. This study aims to determine the effectiveness of using real and virtual laboratories on student science learning outcomes based on students critical thinking skills. With a sample of 80 people, namely students of class IX B and IX D. Each class was divided into groups of high and low critical thinking abilities. The data was taken science learning outcomes data as measured by cognitive test questions that have previously been tested for validity and reliability. Hypothesis testing was done by using a two-way analysis of variance (ANOVA) with treatment by level design. The results showed (1) there were significant differences in learning outcomes between students taught using real and virtual methods and students taught by using real methods (2) there were interactions between learning methods and the ability to think critically on student learning outcomes (3) there were differences significant learning outcomes between students taught using real and virtual methods with high critical thinking skills and students taught using real methods with high critical thinking skills (4) there are differences in learning outcomes between students taught using real and virtual methods with critical thinking skills low and students taught using real methods with low critical thinking skills.

Keywords: real learning methods, learning methods, critical thinking ability, learning outcomes

Introduction

The development of science and technology from time to time is increasingly rapid. This phenomenon results in competition in various fields of life, one of which is education. To print quality human resources is needed to improve the quality of education. The success of education cannot be separated from the role of schools, both public and private schools.

The learning process, in general, is an activity that results in changes in behavior, so the notion of learning is an activity carried out by the teacher in such a way that students behavior changes in a better direction. Achievement of optimal learning outcomes required an educational tool or learning media. The application of learning media must be able to train ways to obtain new information, select it, and then process it so that there are answers to a problem.

Science learning provides a broad space for the development of scientific attitudes, practicing the process of problem-solving, critical thinking, and creative in dealing with problems that exist in society. In fact, science learning in schools is still oriented to the teaching of the material in the form of memorization and problem training. As a result, students critical thinking skills in solving problems are still low.

The laboratory is a support container in schools to conduct experiments in real terms. Practicum is a learning experience where students interact with material or with secondary data sources to observe and understand the natural world. With the practicum, students can be provoked to think critically and be scientific in understanding the concepts given in learning activities and can apply the theories obtained in real life every day.

The learning process of science must be able to provide a series of real and reasonable activities or can be understood by students and enable social interaction, so in the learning process of science students must be directly involved in real activities that allow students to build meaning for themselves. According to Hofstein and Lunetta (1982) "The laboratory has been given a central and distinctive role in science education, and science educators have suggested that there are rich benefits in learning from using laboratory activities". Laboratories have a central role in science education. The use of laboratory activities has many benefits in science learning as suggested by science teachers.

Laboratory activities are planned learning experiences so students interact with learning materials by observing symptoms. Laboratory activities will take place well if supported by laboratory facilities and infrastructure, but the fact that there are laboratory equipment in schools is generally lacking or even none at all.

The development of information technology brings people to be able to find information throughout the world using internet media. This media cannot be separated from developments in the world of computers that are so rapid. The internet as an opening to the world horizon is increasingly contributing meaningfully in the world of education in general. So, one extension of the information needs to be adapted to the learning process in schools. Science and technology are rapidly advancing to offset the needs of the developing community. With the entry of various influences into the world of education such as print sciences, communication, and the pace of development of

electronic technology. In its development, the media appears in various types and formats. The type of media that have been developed lately is computer media. Computers as additional tools in the learning process. The benefits of a computer include the presentation of information, the contents of the subject matter, and training or its combination. This method is known as Computer Assisted Instruction (CAI).

Every junior high school generally has a computer laboratory, so virtual laboratories become an alternative to replace the real laboratory. Some material that has not yet been possible for experimentation using real laboratories, such as atomic models and relativity can use computer facilities as a virtual laboratory medium to conduct experiments. By using a virtual laboratory, students are expected to be motivated and can improve learning achievement.

Critical thinking is a cognitive activity related to the use of reason which means using mental processes, such as paying attention, categorizing, selecting, and judging or deciding. High mind patterns are formed based on critical thinking (Robert H. Ennis, 1995). Some parents and educators agree that in today's society children really need high-thinking skills. Critical thinking is a must in problem-solving, decision making, as an approach, analyzing assumptions, and scientific discoveries. Critical thinking is applied by students to learn to solve problems systematically in facing challenges, solving problems innovatively and designing fundamental solutions. With the implementation of learning in junior high school using laboratory facilities both real and virtual laboratories will improve students' critical thinking skills.

Based on preliminary observations at SMP Negeri 1 Tomohon, in the learning process, several subjects used real laboratory methods. In this study, researchers will compare real laboratory methods plus virtual learning with real laboratory learning methods.

Based on this background, the researcher will conduct a study entitled "The Effectiveness of Real and Virtual Laboratory Use on Students Science Learning Outcomes Based on Students Critical Thinking Ability".

Research Method

This type of research is an experiment, with a Treatment by Level research design using a 2 x 2 factorial design. The study was conducted in March to May 2019, located at SMP Negeri 1 Tomohon. The population in this study were all IX grade students of SMP Negeri 1 Tomohon and the study sample was determined randomly, namely students of class IX B were used as experimental class I and class IX D were used as experimental class II. The total sample is 80 students consisting of 40 students per class.

The design of this study pays attention to the possibility of a moderator variable that influences the treatment (independent variable) on the outcome (dependent variable) with the following design.

Table 1: Research Design

Critical Thinking Ability (B)	Experiment Class (A)	
	A_1 (Real and Virtual Methods)	A_2 (Real Method)
B_1 (High)	A_1B_1	A_2B_1
B_2 (Low)	A_1B_2	A_2B_2

In this design, the assessment is carried out after the treatment is given after the final ability test (posttest) is given.

The instrument used to measure students critical thinking skills is arranged in the form of a questionnaire based on indicators of critical thinking skills (Anggelo, 1995). Determination of the questionnaire instrument scores for critical thinking skills using a Likert scale modified with alternative answers arranged as follows.

Table 2: Gradation of Questionnaire Values

Alternative Answers	Scores for Questions	
	Positive	Negative
Always	4	1
Often	3	2
Rarely	2	3
Never	1	4

For the questionnaire, critical thinking skills as moderator variables are explained in the following table.

Table 3: Questionnaire Grid of Critical Thinking Ability

No	Indicator	Item Number	Sum of Items
1	High Critical Thinking Ability	1,2,3,5,6,9,10,15*,16,17,18*,20,26*,28,29	15
2	Low Critical Thinking Ability	4*,7,8,11,12*,13,14*,19,21,22*,23*,24,25,27*,30	15
Total			30
Information: * Sign for negative statements			

The instrument used to measure learning outcomes is the final test (posttest) in the form of a written test, in the form of 20 multiple choice questions. Before the instrument is used, validity and reliability tests are held. Validity testing is done by using the Pearson Product Moment calculation on the item items that will be tested using SPSS 22 for Windows software.

$$r_{xy} = \frac{n\sum_{i=1}^{n} X_i Y_i - \sum_{i=1}^{n} X_i \sum_{i=1}^{n} Y_i}{\sqrt{\{n\sum_{i=1}^{n} X_i^2 - (\sum_{i=1}^{n} X_i)^2\}\{n\sum_{i=1}^{n} Y_i^2 - (\sum_{i=1}^{n} Y_i)^2\}}}$$

Riduwan, 2006)

With criteria, the questions and questions are declared valid if $r_{count} > r_{table}$. Reliability testing in this study uses the Cronbach's Alpha formula using SPSS 22 for Windows software, as follows:

$$CA = \left[\frac{k}{k-1}\right]\left[1 - \frac{\sigma_b^2}{\sigma_t^2}\right]$$

Reliable classification is as follows
> 0.90 very highly reliable
0.80- 0.89 highly reliable
0.70- 0.79 reliable
0.60- 0.69 marginally reliable
< 0.60 unaccaptabely low reliability
(Cohen et al, 2007)

Before a statistical test is carried out, normality and homogeneity tests are carried out. The normality test is used to determine whether the distribution of research data for each variable has spread normally. In this study, the data normality test uses the Kolmogorov-Smirnov test with the SPSS 22 for windows program. With criteria, the data is normally distributed if the probability value produces a significant value > 0.05.

The homogeneity test is used to find out two or more groups of sample data coming from populations that have the same variance or not. The homogeneity test in this study was analyzed using the Levene Statistic test with the SPSS 22 for Windows program by looking at the comparison of Levene Statistic values with a real level of 0.05. If the significance value of the statistical test results is > 0.05, it can be concluded that the variance in the research subjects is the same or homogeneous.

Hypothesis testing was done by using 2-way ANOVA (analysis of variance) with SPSS 22 for windows. Two-way variance analysis to analyze the influence of independent variables, namely the real method and virtual methods with the moderator variable of critical thinking ability which has two categories, high and low critical thinking skills. Through a two-way analysis of variance, it was expected to find differences in student learning outcomes taught with the use of real plus virtual methods and real methods only. The conclusion whether H_0 is accepted or rejected was obtained by interpreting the significant value in the test of between-subject effect table. The criteria used in drawing conclusions are if the p value is < 0.05 then H_0 is rejected, H_1 is accepted.

The statistical hypothesis of the study is the Treatment by Level 2 x 2 design, namely:

1. The first hypothesis:

H_0: $\mu A1 \leq \mu A2$
H_1: $\mu A1 > \mu A2$

2. The second hypothesis:

H_0: interact A x B = 0
H_1: interact A x B $\neq$ 0

3. The third hypothesis:

H_0: $\mu A1B1 \leq \mu A2B1$
H_1: $\mu A1B1 > \mu A2B1$

4. The fourth hypothesis:

H_0: $\mu A1B2 \geq \mu A2B2$
H_1: $\mu A1B2 < \mu A2B2$

Results and Discussion

Based on the results of research on experimental class I and II, four groups of data were obtained, namely: 1) data on the application of real and virtual methods with high critical thinking skills, 2) data on the application of real and virtual methods with low critical thinking skills, 3) data on the application of real methods with high critical thinking skills, 4) data on the application of real methods with low critical thinking skills.

Data from the cognitive test (posttest) experimental class I and II details of the calculation can be seen in the following table.

Table 4: Posttest data of experimental classes I and II

Experimental Class	Critical Thinking Ability	Mean	Std. Deviation	N
Real and Virtual Methods	High level	90.0945	5.31975	20
	Low level	78.3420	8.99775	20
	Total	84.2183	9.41512	40
Real Method	High level	74.7635	7.80034	20
	Low level	73.9055	7.34166	20
	Total	74.3345	7.48935	40
Total	High level	82.4290	10.18313	40
	Low level	76.1238	8.41116	40
	Total	79.2764	9.80728	80

Testing of Research Instruments

For the validity of the questions as many as 25 items with the criteria of $r_{count} > r_{table}$ obtained 20 valid questions and 5 items that are invalid. Valid questions were used to measure student learning outcomes. The results of testing the validity of the calculation details can be seen in the following table.

Table 5: Results of calculation of the validity of the question instrument

Question Number	Calculation of Validity	Question Number	Calculation of Validity
1.	0.471	14.	0,570
2.	0,449	15.	0,562
3.	0,562	16.	0,799
4.	0,483	17.	0,799
5.	0,308	18.	0,864
6.	0,555	19.	0,719
7.	0,555	20.	0,007
8.	0,555	21.	0,373
9.	0,555	22.	0,483
10.	0,522	23.	0,007
11.	0,864	24.	-0,047
12.	0,796	25.	0,117
13.	0,799		
14.	0,570		

It appears that valid questions or questions are questions number 5, 20, 23, 24, 25 and invalid questions are number 1,2,3,4,6,7,8,9,10,11,12,13, 14, 15, 16, 17, 18, 19, 21, 22. The question is called to be valid if $r_{count} > r_{table}$ where r_{table} of n = 40 is 0.312. Question reliability test data can be seen in the following table.

Table 6: Reliability Test Data

Cronbach's Alpha	N of Items
.889	25

Based on Table 6, it can be seen that the reliability test shows the Cronbach's Alpha number is 0.889 > 0.60 with the highly reliable classification. This shows that the items used can be said to be reliable.

Data Requirements Analysis of Statistical Assumptions

One of the conditions for using a variance analysis technique is the fulfillment of a normality test. In groups A1, A2, B1, and B2 there were 40 respondents and in groups A1B1, A1B2, A2B1, and A2B2 each of the 20

respondents. Normality testing uses the Kolmogorov Smirnov test, if the p value is > 0.05, then the data spread normally.

Table 7: Testing for normality

	Kolmogorov-Smirnov[a]		
	Statistic	**Df**	**Sig.**
A1	.122	40	.139
A2	.093	40	.200*
B1	.100	40	.200*
B2	.093	40	.200*
A1B1	.187	20	.065
A1B2	.157	20	.200*
A2B1	.184	20	.074
A2B2	.118	20	.200*

The test results show that all groups of data come from populations that are normally distributed, so the first requirements for normal data testing have been met.

Homogeneity testing in this study used the Levene Statistic test with SPSS 22 for Windows software, namely by looking at the comparison of Levene Statistic values with a real level of 0.05. If the significance value is from the statistical test > 0.05, it can be concluded that the variance in the research subjects is the same or homogeneous.

Table 8: Homogeneity testing

	Levene Statistic	**df1**	**df2**	**Sig.**
A1 and A2	.390	1	78	.534
B1 and B2	.598	1	78	.442
A1B1, A1B2, A2B1, and A2B2	1.165	3	76	.329

Test results show that all groups of data come from populations that have the same or homogeneous variance, so the data homogeneity test requirements have been met

Hypothesis Testing

Calculation of differences in the average learning outcomes between treatment groups was carried out by two ways ANOVA test with treatment by level design using SPSS 22 software for Windows.

Table 9: Results of Hypothesis Test Calculations with Two Ways ANOVA

Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Corrected Model	3342.344[a]	3	1114.115	19.895	.000
Intercept	502779.491	1	502779.491	8978.023	.000
Experiment Class	1953.770	1	1953.770	34.888	.000
Critical Thinking Ability	795.124	1	795.124	14.198	.000
Experiment Class * Critical Thinking Ability	593.451	1	593.451	10.597	.002
Error	4256.086	76	56.001		
Total	510377.921	80			
Corrected Total	7598.431	79			
a. R Squared = .440 (Adjusted R Squared = .418)					

It can be seen that the probability value (sig) of the experimental class variable is 0,000, with the hypothesis testing criteria if the probability value is < 0.05 then H_0 was rejected. Thus, for the first hypothesis, H_1 was accepted so that there are differences in the average student learning outcomes taught by using real and virtual methods and those taught using the real method learning model only. The second hypothesis testing criteria, the interaction between learning models and critical thinking skills is if the value of sig < 0.05, then reject H_0, because the probability value of the experimental class * critical thinking ability is 0.002, thus the second hypothesis H1 is accepted, so there is interaction between the models learning and critical thinking ability to student learning outcomes.

Further Testing with t-Dunnet

Because testing the influence of the interaction between the learning model and critical thinking skills is significant, it must be tested which average population is truly different through the post hoc test. Before the post hoc test was carried out, a difference test was carried out from four treatment groups by applying the One Way ANOVA test procedure.

Table 10: One Way ANOVA Calculation Results

	Sum of Squares	**Df**	**Mean Square**	**F**	**Sig.**
Between Groups	3342.344	3	1114.115	19.895	.000
Within Groups	4256.086	76	56.001		
Total	7598.431	79			

It was seen that F_{count} = 19,895 > F_{table} = 2.72, then there are differences in the mean between the four treatment groups. After getting the results, it was followed by a post hoc test with the Dunnett t-test.

Table 11: Post Hoc Test Testing Results with the Dunnett t-Test

		Mean Difference (I-J)	**Std. Error**	**Sig.**
1B1	A2B1	15.33100*	2.1112	.000
A1B2	A2B2	4.43650	2.59672	.440
*. The mean difference is significant at the 0.05 level.				

It can be seen that the results of the analysis show the significant value between the application of real and virtual methods with high critical thinking skills and the application of real methods with high thinking skills of 0.000 < 0.05. Furthermore, the significance value between the application of real and virtual methods with low critical thinking skills and the application of real methods with low critical thinking skills is equal to 0.440 > 0.05. Guided by the test criteria if the significance > 0.05 then reject H_1, so it can be stated that there are significant differences in the average learning outcomes between students who learn to use real and virtual methods and real methods with high and low critical thinking skills.

Discussion

The results of testing the first hypothesis show that the learning outcomes of groups of students who use real and virtual methods are higher than the learning outcomes of groups of students who use the real method. These results

can be seen from the average learning outcomes where the experimental group I with the real and virtual methods has an average value of 84.21 and the experimental group II with the real method has an average value of 74.33. Based on the results of the two way ANOVA test it was known that the significance value of the experimental class variable is 0,000 <0.005, meaning that there are differences in student learning outcomes taught by using real and virtual methods and students taught using real methods.

Based on the observations of researchers, learning outcomes that use real and virtual methods are better than the real method alone. This is because in the two experimental classes, the learning process takes place naturally in the form of activities students work and experience, not the transfer of knowledge from teacher to the student then observes the process and concludes the results of experiments, where the experiments conducted relate to objects encountered by students in life daily. In addition, students can work actively in groups so as to enable positive interactions between students and not to get bored in teaching and learning activities. The difference lies in the experimental class 1 virtual method was added, so before students go down directly carry out the practicum, the teacher provides practical instructions through a virtual method where there are animations related to the subject of electrical circuits. This makes students more motivated to learn because of the combination of two methods, namely real and virtual.

The results of testing the second hypothesis show that there is an influence of the interaction between learning methods and the ability to think critically on student learning outcomes. Based on the results of two-way ANOVA test calculations, the interaction of learning methods and critical thinking skills is significant 0.002 <0.005, meaning that there are significant interactions between learning methods and the ability to think critically on student learning outcomes. This shows that there is a significant influence between critical thinking skills in the high and low groups by using real and virtual learning methods on learning outcomes.

The results of testing the third hypothesis show that groups of students with high critical thinking abilities who use real and virtual methods give higher results than groups of students with high critical thinking abilities who use the real method. The average student learning outcomes using real and virtual methods with high critical thinking skills is 90.09 while the average learning outcomes of students who use the real method with high critical thinking skills is 74.76. Based on the results of post hoc calculations with t-Dunnet get a significant value of 0.000 < 0.05. Thus the real and virtual method group learning outcomes with high critical thinking abilities differ significantly from the real method group with high critical thinking skills.

Based on the results of researchers in the field, students who have high critical thinking skills taught by real and virtual methods have higher values because they are better able to understand and analyze problems so they are able to understand the topic better. They can master the material through the process of working together in small groups, practicing thinking skills in solving problems given and increasingly enriching their learning experiences.

The results of testing the fourth hypothesis show that groups of students with low critical thinking abilities who are taught using real and virtual methods give higher results than groups of students with low critical thinking skills who are taught using real methods. The average student learning outcomes using real and virtual methods with low critical thinking skills is 78.34 while the average learning outcomes that use the real method with critical thinking skills are low at 73.90. Based on the results of post hoc calculations with t-Dunnet get a significant value of 0.440 > 0.05. Thus the results of group learning of real and virtual methods with high critical thinking abilities differ from those of the real method group with high critical thinking skills.

Based on the results of researchers in the field, students who have low critical thinking skills taught by real and virtual methods have higher values than they teach with the real method. This is because in the experimental class I there is a combination of real and virtual methods while in the experimental class II there are only real methods. So, both the high and low critical thinking skills of the experimental class I will be superior to the experimental class II.

In accordance with the research conducted by Mulyono (2011) about the effectiveness of using real and virtual experimental methods on problem-based physics learning on students high-level thinking abilities, the average student learning outcomes in the class applied real experimental methods are higher than the classes applied methods virtual.

Conclusion

Based on the results of the study the conclusions are as follows:

1. There are significant differences in learning outcomes between students taught using real plus virtual methods and students taught using real methods.
2. There is an interaction between learning methods and the critical thinking skills on student learning outcomes
3. There are significant differences in learning outcomes between students taught using real methods plus virtual with high critical thinking skills and students taught using real methods with high critical thinking skills
4. There are significant differences in learning outcomes between students taught using real methods plus virtual with low critical thinking skills and students taught using real methods with low critical thinking skills

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