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Differences in the use of problem based learning and discovery learning models of student learning outcomes based on critical thinking ability of students

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Abstract
The situation of teachers who have never measured the critical thinking skills of students and teachers who have not applied a model that can influence students' critical thinking skills, resulting in low student learning outcomes in science subjects. This study aims to determine the differences in the Problem Based Learning and Discovery Learning models on student learning outcomes based on students critical thinking abilities. The population in this study were VII grade students of SMP Negeri 1 Tomohon with a sample of 80 people, namely students of class VII B and VII E. Each class was divided into high and low critical thinking groups. 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 of this study indicate (1) there are significant differences in learning outcomes between students taught using the Problem Based Learning model and students taught using the Discovery Learning model (2) there is an interaction effect between the use of learning models and the ability to think critically on student learning outcomes (3) there are significant differences in learning outcomes between students taught using the Problem Based Learning model with high critical thinking skills and students taught using Discovery Learning models with high critical thinking skills (4) there are significant differences in learning outcomes between students taught using the Model Problem Based Learning with low critical thinking skills and students taught using Discovery Learning models with low critical thinking skills.

Keywords: problem based learning model, discovery learning model, critical thinking ability, learning outcomes

Introduction

Education is something that cannot be separated from human life. Education occupies an important position in the development of a nation. Education consists of various interrelated elements to achieve goals, from that it can be called that education as a system that cannot be separated from the environment both physical and other living beings because education also requires lessons from nature or the surrounding environment.

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. With science learning students gain a long-lasting understanding of the various facts of the ability to recognize and solve problems and have a scientific attitude. Science learning can develop the ability of inductive and deductive analytical thinking in solving problems related to natural events, both qualitatively and quantitatively, and can develop knowledge, skills, and self-confidence attitudes. For this reason, it is expected that students who are learning it will realize and find the existence of various symptoms and each symptom contains problems that need to be solved. Thus through science learning students are encouraged to use their thinking skills in solving problems in everyday life.

Generally, science learning is actually known as a subject that is “feared” and disliked by students. This usually starts with the learning experience of these students. In addition, science learning is very boring because the teacher still survives in the classical learning model which is dominated by lecture activities where the flow of information is more one-way and teacher-centered activities. This results in weak critical and creative abilities that lead to low student abilities.

Based on preliminary observations at the SMP Negeri 1 Tomohon, there were several problems found among them, namely the lack of students who had critical thinking skills. Through preliminary observations, from around 40 students in one class, only 10 students seemed critical or often gave opinions during learning. Teachers are only limited to measuring the learning outcomes of science and have never measured students' thinking abilities. The teacher has not applied the models, strategies, and methods that can affect students' critical thinking skills. Thus, the teacher has never seen the influence of a particular model based on the students' critical thinking abilities.

The existence of the problems described above will be carried out the research by using a learning model that can improve learning outcomes in terms of students critical thinking skills. Researchers will conduct research using problem-based learning and discovery learning.

The reason the researchers chose the two models is the discovery and problem-based model of students can be directly involved in demonstrating, showing, observing, recording everything that happens in learning activities (Rosana, 2014) [5]. With this model, students will be impressed by what they see and experience so that students are expected to be trained to develop critical thinking skills

during the learning process so that they can draw conclusions from the process of activities well in order to improve student learning outcomes (Daryanto, 2014) [2].
Based on this background, the researcher conducted a study entitled "Differences in the Use of Problem Based Learning and Discovery Learning Models for Student 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 students of class VII of SMP Negeri 1 Tomohon and the study sample was determined randomly namely, students of class VII B were used as experimental class I and class VII E which 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 (Problem Based Learning Model)	A_2 (Discovery Learning Model)
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 using ANOVA (analysis of variance) 2 paths with the help of SPSS 22 for Windows. Two-way variance analysis to analyze the influence of

independent variables, namely problem based learning models and discovery learning models with moderator variables of critical thinking ability which have two categories, namely high and low critical thinking skills. Through a two-way variance analysis, it is expected to find differences in learning outcomes of students who teach with the use of problem-based learning models and discovery learning models. The conclusion whether H_0 is accepted or rejected is obtained by interpreting the significant value in the test of between-subject effect table. The criteria used in 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: μA1 ≤ μA2
   H_1: μA1 > μA2
2. The second hypothesis:
   H_0: interact A x B = 0
   H_1: interact A x B ≠ 0
3. The third hypothesis:
   H_0: μA1B1 ≤ μA2B1
   H_1: μA1B1 > μA2B1
4. The fourth hypothesis:
   H_0: μA1B2 ≥ μA2B2
   H_1: μA1B2 < μA2B2

Results and Discussion

Based on the results of research in the experimental classes I and II, four groups of data were obtained, namely: 1) data with the application of the problem-based learning model with high critical thinking skills, 2) data with the application of problem-based learning models with low critical thinking skills, 3) data with application of discovery learning models with high critical thinking skills, 4) data with the application of discovery learning models 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: Post-test data of experimental classes I and II

Experiment Class	Critical Thinking Ability	Mean	Std. Deviation	N
Problem Based Learning Model	High level	90.0475	5.36346	20
	Low level	79.3465	7.71031	20
	Total	84.6970	8.50522	40
Discovery Learning Model	High level	77.0990	6.82073	20
	Low level	80.4010	6.86229	20
	Total	78.7500	6.95717	40
Total	High level	83.5733	8.92580	40
	Low level	79.8738	7.22420	40
	Total	81.7235	8.28009	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
Cronbach's Alpha	N of Items
.889	25

Cronbach's Alpha	N of Items
.889	25
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	.099	40	.200*
A2	.136	40	.061
B1	.085	40	.200*
B2	.104	40	.200*
A1B1	.183	20	.079
A1B2	.132	20	.200*
A2B1	.181	20	.084
A2B2	.213	20	.068

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	.524	1	78	.471
B1 and B2	.883	1	78	.350
A1B1, A1B2, A2B1, and A2B2	.377	3	76	.770

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	1961.482[a]	3	653.827	14.383	.000
Intercept	534298.436	1	534298.436	11753.877	.000
Experiment Class	707.336	1	707.336	15.560	.000
Critical Thinking Ability	273.726	1	273.726	6.022	.016
Experiment Class * Critical Thinking Ability	980.420	1	980.420	21.568	.000
Error	3454.748	76	45.457		
Total	539714.666	80			
Corrected Total	5416.230	79			

a. R Squared = .440 (Adjusted R Squared = .418)

It is 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 is rejected. Thus, for the first hypothesis H1 is accepted so that there are differences in the average learning outcomes of students taught by using the problem-based learning model and those taught by using discovery learning models. The criteria for testing the second hypothesis, the interaction between the learning model and the ability to think critically is if the sig value is < 0.05, then reject H_0, because the probability value of the experimental class * critical thinking ability is 0,000. Thus, for the second hypothesis H_1 is accepted, so that there is an interaction between the learning model and the ability to think critically on 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	1961.482	3	653.827	14.383	.000
Within Groups	3454.748	76	45.457		
Total	5416.230	79			

It was seen that F_{count} = 14.383 > 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.**
A1B1	A2B1	12.94850*	1.9402	.000
A1B2	A2B2	-1.05450	2.3080	.040

* The mean difference is significant at the 0.05 level.

It can be seen that the results of the analysis show a significance value between the application of the problem-based learning model with high critical thinking skills and the application of the discovery learning model with high thinking skills of 0.000 < 0.05. Furthermore, the significance value between the application of the problem-based learning model and the ability to think critically is low and the application of the discovery learning model with low critical thinking skills is 0.040 < 0.05. Guided by the test criteria if the significance is < 0.05 then accept H_1, so it can be stated that there are differences in the average learning outcomes between students who learn using the problem-based learning model and discovery learning with high and low critical thinking skills.

Discussion

The results of testing the first hypothesis show that the group learning outcomes of students who use the problem-based learning model are higher than the group learning outcomes of students who use discovery learning models. This result can be seen from the average learning outcomes where the experimental group I has an average value of 84.69 and the experimental group II has an average value of 78.75. Based on the results of the Two Way ANOVA test it is known that the significance value of the experimental class variable is 0,000 < 0.05, meaning that there are differences in student learning outcomes taught using the problem-based learning model and students taught using discovery learning models.

Based on the observations of researchers, there are several factors that can make learning outcomes of problem-based learning better than discovery learning, among others, is giving an initial problem that occurs in everyday life at the beginning of problem-based learning. This makes students more motivated to learn to solve the problems posed. Problem-based learning is a learning model that uses real-world problems as a context for students to learn critical thinking and problem-solving skills even students will be more able to learn and understand if they know the meaning of the subject being studied, namely by students rediscovering and constructing their own knowledge learned. Whereas in discovery learning there are difficulties experienced by students, namely the length of the process of drafting the concept, even though the stimulus and assistance to manage the data have been given, but students are still having difficulties so sometimes the teacher must provide the concept. As a result, this does not encourage students to learn.

Based on the learning outcomes of cognitive tests students who are taught with problem-based learning are faced directly with the real learning process. In this class, the learning process becomes more active and fun for students because students can better understand the material learned by linking the problems that they often experience in everyday life. Thus, the scientific activities of students in the learning process will have an effect on student learning outcomes. Whereas in the class taught by discovery learning, the teacher presents short material as a basis for students to solve problems. The material provided can lead to active problem solving from learning discoveries, for example by providing the opposite facts. Thus, the role of the teacher in the learning process causes interactions that arise between students less, so that in the discussion process students tend to understand the subject matter made by the teacher.

The results of testing the second hypothesis show that there is an influence of the interaction between the learning model and the ability to think critically on student learning outcomes. Based on the results of the Two Ways ANOVA test, the interaction of the learning model and critical thinking skills is significant 0.000 < 0.05, meaning that there is a significant interaction between the learning model 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 using the problem-based learning model and discovery learning on learning outcomes.

The results of testing the third hypothesis show that groups of students with high critical thinking abilities who use the problem-based learning model give higher results than groups of students with high critical thinking abilities who use discovery learning models. The average learning outcomes of students who use the problem-based learning model with high critical thinking skills is 90.04 while the average student learning outcomes that use the discovery learning model with high critical thinking skills is 77.09. Based on the results of the calculation of the post hoc test with t-Dunnet get a significant value of 0.000 < 0.05. Thus, the group learning outcomes of problem-based learning models with high critical thinking abilities differ significantly from those in the discovery learning model group with high critical thinking skills.

Based on the results of researchers in the field, students who have high critical thinking skills taught by the problem-based learning model have higher values because they are better able to understand and analyze problems so they are able to understand the material 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 taught using the problem-based learning model yield lower results than groups of students with low critical thinking skills who are taught using discovery learning models. The average learning outcomes of students using the problem-based learning model with low critical thinking skills is 79.34 while the average learning outcomes using discovery learning models with low critical thinking skills are 80.40. Based on the results of post hoc calculations with t-Dunnet get a significant value of 0.040 < 0.05. Thus, the group learning outcomes of problem-based learning models with low critical thinking abilities differ from those in the group of discovery learning models with low critical thinking skills.

Based on the results of researchers in the field, students who have low critical thinking skills taught by the problem-based learning model have lower grades than those taught with discovery learning models. Students who have low critical thinking skills, need to be stimulated by all means to generate critical thinking skills. In the problem-based learning model, students are faced directly with facts in the field, then students are asked to determine what problems they find themselves. Next, students are given assignments to collect data, observations, and others. Students who have the ability to think critically low tend to be lazy to think to find a concept of the problem that will be found. Unlike the

case, of students who have critical thinking skills are low and they are taught with discovery learning models. Students are not asked to determine what problems are in the field, but the teacher who first gives a statement of fact in the form of a problem to be solved. In its implementation, students who are able to think critically low will be invited to hold discussions and he will be motivated in expressing ideas or opinions. This is much easier than he tries to find out for himself. This activity prioritizes group collaboration and sharing of opinions so that students who do not master learning will exchange knowledge and opinions with other group members.

In accordance with the research conducted by Rahayu (2015) [4] about the comparison of student learning outcomes between learning using problem-based learning and discovery learning, found that the average student learning outcomes in the class that applied problem-based learning was higher than the classes applied to discovery learning. Likewise with the research conducted by Sari (2017) about the differences in the application of problem based learning and discovery learning to high-level thinking abilities of class VII junior high school students on the subject of the human circulatory system, concluded that high-level thinking skills of students learning using model problems based learning is different from students learning using discovery learning models. Another conclusion obtained is that the average student learning outcomes in the class applied problem-based learning is higher than the class applied to discovery learning.

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 the problem-based learning model and students taught using discovery learning models
2. There is an interaction between the learning model and the ability to think critically on student learning outcomes
3. There are significant differences in learning outcomes between students taught using the problem-based learning model with high critical thinking skills and students taught using discovery learning models with high critical thinking skills
4. There are significant differences in learning outcomes between students taught using the problem-learning model with low critical thinking skills and students taught using discovery learning models with low critical thinking skills.

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