The Influence of Problem Based Learning Model and Critical Thinking Skills on Students Science Process Skills

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ABSTRACT
This study aims to analyze: The science process skills of students who are taught using the problem based learning model are better than students who use conventional learning, the science process skills of students who have critical thinking skills above average are better than students who have thinking skills. critically below average, and there is an interaction between the problem based learning model and students' critical thinking skills in improving students' science process skills. The research was conducted in a quasi-experimental way with a two-group pretest-posttest design. The research population was students of SMA N 8 Medan. Sampling was done by means of cluster random sampling taking two classes from four classes, namely class X-2 as the experimental class and class X-4 as the control class. The instrument used is an essay test for science process skills and a test for critical thinking skills. The resulting data were analyzed using two-way ANOVA. The results showed that: the science process skills of students who were taught using the problem based learning model were better than students who used conventional learning, the science process skills of students who had critical thinking skills above average were better than students who had critical thinking skills. below average and there is an interaction between the problem based learning model and students' critical thinking skills in improving students' science process skills.

Keywords: *Problem Based Learning, Critical Thinking Skills, Science Process Skills.*

1. INTRODUCTION

Quality human resources come from a quality education process, with skills provision to solve problems, think reflectively, look for alternative solutions, think reflectively and evaluatively. The rationale for developing the 2013 curriculum is to prepare students to face future challenges and achieve learning goals effectively and efficiently. The principle that is currently being adapted is that education does not only transfer knowledge to students but also processes related to cognitive aspects and skills.

Critical thinking skills and science process skills are very important skills possessed by students. Critical thinking skills are important because students can more easily understand concepts, are sensitive to problems that occur so they can understand and solve problems and are able to apply concepts in different situations.

Critical thinking helps students to express their opinions on scientific or social problems, make decisions, construct and solve their problems. Critical thinking is a skilled and active interpretation and evaluation of observation and communication, information and argumentation.

Critical thinking is the ability to organize, analyze and evaluate arguments, mental processes, strategies and representations of a person used to solve problems, make decisions and learn new concepts and reflective thinking that makes sense or based on reasoning that is focused on determining what to do. Critical thinking skills are important because they provide space for students to ask questions, make assumptions, analyze, and evaluate.

The next practical skill in physics that is important for students to have is science process skills. Science process skills are psychomotor skills used in problem solving. Science process skills include problem identification, objective investigation, data collection, transformation, interpretation and communication. Science process skills are skills that facilitate science learning so as to enable

students to be active in solving problems and developing a sense of responsibility using the scientific method.

The reality in the field of research conducted shows in their respective studies that students' critical thinking skills are at a low level. This is supported by the results of a preliminary study at SMA Negeri 8 Medan that students were unable to answer the critical thinking test questions correctly. This fact is supported by the results of student interviews which state that students rarely find critical thinking skills tests such as tests in preliminary studies at school. Based on the results of interviews with teachers, critical thinking skills tests were never given to students because they were considered complicated and difficult to solve. The test given to students is in the form of questions with the categories of remembering (C1), understanding (C2) and calculating (C3).

Another fact shows that physics learning is conventional with monotonous learning with lectures that still emphasize material explanations, problem solving, assignment assignments without emphasizing interaction with students. This kind of learning results in a lack of opportunities to participate in experimental activities in the laboratory. Students rarely do practicum so that during practicum many are confused in participating in the experiment on the activity sheet, less able to discuss, less able to propose hypotheses and draw conclusions. This learning situation causes a lack of students' scientific process skills.

One alternative to improve students' critical thinking skills and science process skills is to use a problem based learning model, because it helps students develop science process skills and develop students' knowledge. Problem based learning learning models can improve students' science process skills. Problem based learning models can build students' scientific process skills because problem based learning can involve students actively (student center) to investigate the problems presented on student worksheets, provide experience and familiarize students with managing and discovering their own knowledge.

Problem-based learning is closely related to science process skills such as observing, inferring, clarifying, estimating, measuring, questioning, interpreting, and analyzing data. not only includes science process skills, problem based learning also combines scientific knowledge processes, scientific reasoning and critical thinking to develop scientific knowledge. Problem-based learning helps students develop critical thinking skills and allows students to build knowledge like a scientist. The results of the study that problem based learning has a significant effect on students' critical thinking skills in science and technology knowledge. Problem Based Learning can help improve the learning experience of students, increase their awareness of the basics related to the scientific process and ultimately help prepare them for a career in science.

Based on the above background, it is important to conduct research to overcome problems by applying learning models to improve students' critical thinking skills and science process skills with the title "The Effect of Problem Based Learning Models and Critical Thinking Skills on Students' Science Process Skills."

2. RESEARCH METHODS

2.1. Types of research

This type of research is a quasi-experimental research that is intended to determine whether there is a consequence of something imposed on the subject, namely students. This study involved two classes of samples that were given different treatments. The experimental class uses a Problem Based Learning model, while the control class uses conventional learning.

2.2. Research design

The research design is a two group pretest-posttest as shown in Table 1.

Table 1. *Two Group Pretest-postest Design*

Class	Pretest	Treatment	Postest
Exp	X_1	Y_1	X_2
Control	X_1	Y_2	X_2

Information*:*

X_1 = Pre test in the experimental class and control class before being given treatment

Y_1 = Treatment for problem based learning models

Y_2 = Post-test in the experimental class and control class after being given treatment

X_2 = Treatment for conventional learning models

At the end of the experiment both groups were tested with the same measuring instrument and became experimental data. In this regard, the research design can be presented with a 2 x 2 factorial design with a 2-way analysis of variance (ANAVA) technique as presented in the following table.

Table 2. Anova Research Design

Critical Thinking Skills (B)	Learning Model (A)		Mean
	Conventional	Problem based learning	
Above Mean (B_1)	A_1B_1	A_2B_1	μB_1
Below Mean (B_2)	A_1B_2	A_2B_2	μB_2
Mean	μA_1	μA_2	

Information*:*

A_1B_1: A group of students who are taught using the problem based learning model of students who have above average critical thinking skills.

A_1B_2: A group of students who are taught using a problem based learning model with students who have below average critical thinking skills.

A_2B_1: A group of students who are taught using conventional learning with students who have above average critical thinking skills.

A_2B_2: A group of students who are taught using conventional learning with students who have below average critical thinking skills.
μA_1 : The average science process skills of students who are taught by conventional learning.
μA_2 : The average science process skills of students who are taught using the problem based learning model.
μB_1 : The average science process skills of students who have critical thinking skills are above the average.
μB_2 : The average science process skills of students who have critical thinking skills are below the average.

2.3. Location and Time of Research

In accordance with the title of this study, the research location was carried out at SMA Negeri 8 Medan Jl. Sampali No.23 Medan will be held in the even semester of the 2020/2021 Academic Year.

2.4. Population and Research Sample

The population of this study was all students of class X SMA Negeri 8 Medan in the even semester of T.P 2020/2021.
The research sample is part of the population. The sample in this study was 2 classes taken by cluster random sampling, namely sampling with a randomization process which was presented as 1 experimental class (X1) with Problem Based Learning learning model and 1 control class (X2) with conventional learning strategies.

2.5. Test Validity

Validity is the degree of accuracy between the data that occurs in the object of research and the power that can be reported by researchers (Sugiyono, 2017). Basically there are two kinds of instruments that will be used in this research, namely non-test instruments to measure science process skills and test instruments to measure critical thinking skills.

2.6. Data Analysis Technique

Before testing the hypothesis, a prerequisite test for data analysis is carried out. The data analyzed in this study is the result of science process skills and critical thinking skills given to students.

3. RESEARCH RESULTS

3.1. Science process Skills Pretest

The data in the results of this study consisted of the results of science process skills and students' critical thinking skills using conventional models in the control class and problem based learning models in the experimental class.
At the beginning of the study, both classes were given a pretest to see the results of students' science process skills and critical thinking skills before being given treatment with different learning models. The results of the research on science process skills pretest scores are shown in Table 3.

Table 3. Control and Experiment Class Pretest

Control		Experiment	
Value	Frequency	Value	Frequency
35	2	35	1
40	2	40	9
45	16	45	4
50	9	50	9
55	1	55	4
		60	3
Total	**30**	**Total**	**30**
Mean	**46,33**	**Mean**	**48,00**
Std.Deviation	**4,82**	**Std.Deviation**	**6,34**

Table 3. shows the results of the control class pretest 46.33 and the experimental class pretest 48.00. The following is a graph of the pretest in the control and experimental classes.

3.2. Critical Thinking Skills

Experimental and control class students will be divided into two groups, namely the group with above average critical thinking skills are students who have critical thinking skills equal to and more than while the below average students are smaller. For more clearly the division of critical thinking skills can be seen in Table 4.

Table 4. Grouping of Students based on Critical Thinking Skill Level in Control and Experiment Classes

High Experiment Class		Low Experiment Class	
Value	Frequency	Value	Frequency
44	1	24	1
48	1	32	1
56	2	48	1
60	1	52	1
64	4	56	5
68	2	60	5
72	4	64	3
76	6	68	2
80	5	72	1
84	4	76	4
		80	5
		84	1
Total	**30**	**Total**	**30**
Mean	**71,2**	**Mean**	**46,13**

Based on the table, the number of groups of students who have high critical thinking skills is greater than students who have low critical thinking skills. This grouping is used when testing two-way ANOVA when testing hypotheses.

3.3. Science process Skills Postest

After finishing processing the results of the pretest data, then proceed with the results of the posttest data on science process skills after being given different treatment in the two classes. Then the data obtained in Table 5.

Table 5. Control and Experiment Class Postest

Control		Experiment	
Value	Frequency	Value	Frequency
35	2	60	2
40	2	65	8
45	16	70	3
50	6	75	9
55	3	80	5
60	1	85	3
Total	**30**	**Total**	**30**
Mean	**47,33**	**Mean**	**73,00**
Std.Deviation	**4,82**	**Std.Deviation**	**6,91**

The two classes have different average values, for the control class the average value is 47.33 while the average value for the experimental class is 73.00. So it can be concluded that the science process skills in the experimental class are higher than the control class. The following is a post-test chart for the control and experimental classes.

3.4. Data analysis

3.4.1. Data Analysis Prerequisite Test

As a condition for being able to perform data analysis, the researcher must perform the prerequisites for data analysis, namely by calculating normality and calculating homogeneity. The results of the normality calculation can be seen in the following table:

Table 6. Normality Calculation Results

Group	Variable	Kolmogorov		Conclusion
		Z	Asymp sig	
Science process Skills Pretest	Experiment	0,157	0,145	Normal
	Control	0,139	0,057	Normal
Science process Skills Postest	Experiment	0,153	0,145	Normal
	Control	0,139	0,069	Normal

From the results of the analysis of homogeneity calculations using SPSS 21.0 for window, the following summary of the levene test statistical values is obtained:

Table 7. Homogeneity Calculation Results

Category	Levene Statistic	Asymp sig	Conclusion
Science process Skills Pretest	2,157	0,147	Homogen
Science process Skills Postest	5,119	0,270	Homogen

From the table above, it can be seen that the significance value of the levene test results in both the experimental and control groups has a significance value greater than $\alpha = 0.05$. Thus it can be concluded that the variance of the two classes is homogeneous.

3.4.2. Testing Hypotheses

The statistical description of the output of ANOVA post-test data on science process skills and critical thinking skills can be seen in the table. Based on the test results, the average value of low critical thinking skills on science process skills in the control class was 48.14. Meanwhile, high critical thinking skills in science process skills in conventional classes are 47.08.

The average value of low critical thinking skills in conventional class science process skills is better than the average high critical thinking skills. This shows that critical thinking skills as a moderating variable in the control class weaken students' science process skills as seen from the average results of students' critical thinking skills.

The average value of low critical thinking skills on science process skills in the problem based learning (experimental) class is 71.05. Meanwhile, high critical thinking skills in science process skills in problem based learning (experimental) classes are 76.36. The average value of high critical thinking skills in problem based learning (experimental) class in science process skills is better than high critical thinking skills in science process skills in conventional (control) classes. Descriptively, based on 2-way Anova statistics, the average science process skills were obtained.

Table 8. Anova Research

Learning / Critical Thinking Skills	Conventional (A_1)	*Problem Based Learning* (A_2)	Mean
Above Mean (B_1)	48,14	76,36	61,72
Below Mean (B_2)	47,08	71,05	59,59
Mean	47,61	73,70	60,65

The results of ANOVA in the critical thinking class column have a significant value of 0.003. With a significance value of 0.003 < 0.005. This shows that the test results reject H_0 or accept H_a in a significant level with an alpha of 0.05. Thus the author states that there is an influence between the problem based learning model and critical thinking skills in improving students' science process skills.

4. DISCUSSION OF RESEARCH RESULTS

4.1. Students Science Process Skills with Problem Based Learning are better than Conventional Learning

Based on the hypothesis testing that has been done, it can be concluded that the science process skills of students who are taught using the Problem Based Learning model are better than those who are taught by conventional learning.

Problem based learning model is a series of learning that improves the process of critical thinking and analytical skills to seek and find their own answers to a physics problem. The effect is that the problem based learning model will improve scientific understanding, productivity in creative thinking, and skills in analyzing information.

The results of the study show that problem based learning teaching techniques are very influential for students compared to conventional teaching, this is based on tests conducted by the author to determine the level of students' science process skills. The ANOVA test results obtained 0.000 < 0.005 indicating that the problem-based learning model of students' science process skills will increase compared to conventional learning. So that the comparison of the average arithmetic process skills of experimental class students increased by 5% from the control class.

The combination of science process skills in both classes was seen after getting treatment. This happens because the problem-based learning model of students is more free to communicate the findings they get when carrying out learning activities. Communication between friends provides a quick solution for students to complete their ignorance of the subject matter being studied. Then added with use so that students better understand the learning process. This further researches concluding that the problem based learning model will improve students' science process skills.

The results of this study are in line which concludes that students' science process skills taught by problem based learning model show better results than students taught by conventional learning. This is also obtained concluding that the science process skills of students with problem based learning are better than the science process skills of students using conventional models. Her research concluded that the science process skills of students who were taught using a problem based learning model were better than conventional learning. These results indicate the influence of the problem based learning model on the science process skills of students.

The conclusion of this analysis is the students' science process skills in using observation indicators, asking questions, finding patterns and relationships, designing, measuring and calculating the compared classes. The average value of the overall science process skills obtained by students was higher in the experimental class than in the control class.

Unlike the conventional case, which focuses on the training process for students. Students only listen, work on questions, and answer questions given by the teacher. This learning activity does not provide opportunities for students to hone their thinking skills and abilities. Knowledge cannot last long in the memory of students, so that students' science process skills become low.

4.2. Science Process Skills Learners have Critical Thinking Skills Above Average Better than Students who have Critical Thinking Skills Below Average

The importance of science given in education has been realized by everyone. Science not only aims to provide some knowledge about the universe but also teaches students to be able to think critically. Explains that science is composed of processes and products where the process is the scientific method and the product is scientific knowledge and scientific attitudes with the development of students' critical thinking skills.

Thinking skills affect students' science process skills (KPS) in solving problems related to formulating hypotheses. The process of science requires critical skills in solving problems. Based on the characteristics of students with above average skills related to the ability to think critically, carefully, efficiently and effectively and of course, the level of reasoning will be higher in solving problems than students who are below average. This critical thinking skill plays an important role in the science process skills achieved by students.

The results obtained in this study indicate that critical skills are very influential on the science process of students as indicated by the ANOVA test of 0.000 < 0.005. Factors that influence, namely: intelligence, attention, interest, talent, motive, maturity, and fatigue. Students with good critical thinking skills are able to solve problems better than students with low thinking skills.

The thinking style or mindset of students will affect students' science process skills marked by their skills in finding new ideas or alternative answers in planning and solving problems. This is in line with, students who have more than one thinking style and have the same skills in managing information will get good achievements in learning. Furthermore, concluded that there were significant differences in the assessment of knowledge at the lower and upper levels.

4.3. Interaction between Problem Based Learning Model and Critical Thinking Skills on Science Process Skills

The problem based learning learning model presents subject matter in this case by exposing students to problems that can develop thinking skills, where students not only accept the theory but are also directly involved in the process of accepting the theory.

The results of basic science process skills show that there is a significant effect between conventional approaches and problem solving approaches on basic science process skills. Significant means that there are differences in student activities before and after being given treatment, namely the application of a problem-solving approach in learning. Explains that the basic principle for developing science process skills for elementary students is to observe and use available information sources.

The results of the study also revealed that students' critical thinking skills taught by problem based learning were better than students' critical thinking skills taught by conventional learning. The results of this study are in line with research conducted. The research conducted shows that there is a difference in students' critical thinking skills between the classes that are given learning with problem based learning which is higher than conventional learning. This study is also in line with research conducted which states that problem-based learning models are significantly effective in improving cognitive and effective learning outcomes and attitudes of students compared to conventional ones. In line with that, the conclusion of research conducted, that students' research skills can be improved by applying problem based learning so that science process skills have high critical thinking skills.

Learning orientation is finding new knowledge. In learning, students are required to seek and find the problems given. Students are faced with problems, collect data theoretically, collect data experimentally, process and formulate explanations and analyze the research process. The ideal learning situation is more interactive, that is, students are expected to be willing to accept challenges in the process of finding the cause of the problem. The problems given must be problems whose solutions are affordable for students' abilities. Through this interaction, thinking skills and knowledge in long-term memory will be obtained to answer physics problems related to physics concepts, so that they can obtain critical thinking skills to the maximum in other words, problem based learning and critical thinking models can both improve students' science process skills in solving physics problems. This is in line, good learning of concept maps if carried out at all stages is able to strengthen memory so that more information can be remembered so that students tend to achieve higher achievements.

The test results obtained $0.003 < 0.005$ indicates there is an interaction of problem-based learning models and critical thinking skills in improving students' science process skills. In this study, students who have high critical thinking skills are more dominant in improving students' science process skills in the problem based learning model of conventional learning. This can also be seen from the results of the interaction testing of high critical thinking skills in the conventional class and high critical thinking skills in the problem based learning class and the interaction of low critical thinking skills in the conventional class with low critical thinking skills in the problem based learning class. That is, problem-based learning models and high critical thinking skills will obtain high science process skills or conversely problem-based learning models and low critical thinking skills will acquire low science process skills. This is in line learning model and motivation to influence each other, students who have high motivation with the learning model will get high learning outcomes, or vice versa students who have low motivation with the learning model will get low learning outcomes.

5. CONCLUSION

Based on the results of the analysis and discussion in this study, the following conclusions can be drawn:

a. Students' science process skills taught by using the Problem Based Learning model are better than students' science process skills taught by conventional learning models. Students who are taught with problem based learning learning model get an average of 73.00 and students who are taught using conventional learning get an average of 48.00. This research shows that there is an effect of problem based learning model on science process skills.

b. Science process skills of students who have critical thinking skills above average are better than students who have below average critical thinking skills. The science process skills of students whose critical thinking is above the average are 71.20 and the science process skills of students whose critical thinking is below the average are 46.13. This shows that there is an influence of critical thinking skills on science process skills.

c. There is an interaction between the problem based learning model and critical thinking skills in improving students' science process skills. Therefore, students above the average (high) have a significant effect on science process skills in the experimental class. Meanwhile, the control class did not have a significant effect on students' science process skills.

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REFERENCES

[1] Aslan, O. (2015). How Do Turkish Middle School Science Coursebooks Present the Science Process Skills. *International Journal of Environmental & Science Education, 10* (6), 829-843.

[2] Bahtiar, Wasis., & Rahayu. (2016). A Problem Based Learning Approach-Based Physics Practice Model To Improve Students' Critical Thinking Skill. *International Conference on Education (IECO), 1*, 96-108.

[3] Bensley, D. A., & Spero, R. A. (2014). Improving critical thinking skills and metacognitive monitoring through direct infusion. *Thinking Skills and Creativity, 12*, 55–68.

[4] Duran, M., & Dokme. (2016). The Effect Of Problem Based Learning On Student's Critical-Thinking Skills. *Eurasia Journal of Mathematics, Science & Technology Education, 12 (*12), 1-22.

[5] Ergul & Remziye. (2011). The Effects Of Problem Based learning Science Teaching On Elementary School Students' Science Process Skills and Science Attitudes. *Bulgarian Journal of Science and Education Plicy (BJSEP),* 5 (1), 48-67.

[6] Foster, J.S., & Lemus, J.D. (2016). Developing the Critical Thinking Skillsof Astrobiology Students through Creativeand Scientific Inquiry. *Astrobiology, 15*, 89-99.

[7] Fuad, N. N., Zubaidah, S., Mahana, S. E., & Suarsini, E. (2017). Improving Juior High Schools Critical Thinking Skills Based on Test Three Different Models Of Learning. *International Journal Of Instruction, 10* (1), 101-116.

[8] Herlina. (2015). Improving Creative Thinking Skillsand Scientific Attitudethrough Problem-Based Learning In Basic Biology Lecture Toward Students Of Biology Education. Jpbi (*Jurnal Pendidikan Biologi Indonesia*. *4*(1), 23-28

[9] Karsli, F. A. (2014). Developing a Laboratory Activity by Using 5e Learning Model on Student Learning of Factors Affecting the Reaction Rate and Improving Scientific Process Skills. *Social and Behavioral Sciences*. *143*, 663-668.

[10] Meliala, et al (2018). *The Effect Of Problem based Learning Model Using On Student's Concept Knowledge, And Science Process Skills In Senior High School*. Jurnal Pendidikan Indonesia. *8* (1), 79-84.

[11] Putri, M. (2017). Efek Model Scientific Inquiry dan Agumentasi Ilmiah Terhadap Keterampilan Proses Sains Peserta didik SMA. *Jurnal Pendidikan Fisika, 6* (1), 20-26.

[12] Safarati, N, Harahap, M.,B., Sinulingga, K., (2017), Pengaruh Model Scientific Inquiry Menggunakan Media PhET Terhadap Keterampilan Proses Sains Ditinjau dari Keterampilan Berpikir Kritis *Jurnal Pendidikan Fisika*, *6* (1), 30 – 38.

[13] Turiman, P., Omar, J., Daud, A.M. & Osman, K. (2012). Fostering the 21st century skills through scientific literacy and science process skills. *Procedia - Social and Behavioral Sciences*, 59, 110 – 116.

[14] Yager, R.E. & Akçay, H. (2010). *The Advantages of an Problem Based Learning Approach for Science Instruction in Middle Grades*. School Science & Mathematics, *110*, 5-12.

[15] Zaini, M. (2016). A Problem Based Learning on the Concept of Ecosystem Toward Learning Outcomes and Critical Thinking Skills of High School Students. *IOSR Journal of Research and Method in Education, 6*, 50-55.