

The Effect of Problem Based Learning (PBL) Model toward Student's Critical Thinking and Problem Solving Ability in Senior High School

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Abstract This research aimed to analyze the gain of students' critical thinking and problem solving ability by using conventional learning; to analyze whether the gain of students' critical thinking and problem solving ability by using problem based learning model better than conventional learning. This research was a quasi experimental research with two group pretest-posttest design. The population of this research was second semester of State Senior High School 1 class X academic year 2016/2017. The sample of this research were two classes that consisted of 70 students by using cluster random sampling technique. Class X MIA-1 as experimental class taught by problem based learning model that consist of 34 students, class X MIA-2 as control class taught by conventional learning that consist of 36 students. The instruments of the research were essay test of critical thinking ability and problem solving ability that consist of 5 questions for each. The data were analyzed by using t-test statistics. The results showed that: the mean gain of students' critical thinking and students' problem solving ability taught by problem based learning was in medium level and the mean gain of students' critical thinking and students' problem solving ability taught by conventional learning was in low level. Hypothesis test showed that the mean gain of students' critical thinking and problem solving ability taught by problem based learning was better than conventional learning, this result showed that there was an effect of problem-based learning model on students' critical thinking and problem-solving ability.

Keywords: *problem based learning model, critical thinking ability, problem solving ability*

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1. Introduction

Nowadays, the measurement of students' learning outcomes is generally concerned on cognitive aspects from low to medium level. Otherwise, the new curriculum demands students to have high cognitive aspects namely critical, creative thinking, and problem solving ability.

Physics is one of the subjects in science that can be used as a tool to develop analytical and deductive thinking ability in solving problems related to natural events. According to Mariati [15], the reality showed that in physics teaching and learning process, students tend to memorize formula but do not understand how and for what the formula used. Lecture and question-answer method are conventional methods used by teachers. The steps are explaining, giving example, asking, exercising, and giving task.

It clearly showed that cognitive learning outcomes of Indonesian students only measure low to medium cognitive level, not high order thinking skill. Otherwise, teacher centered learning caused lack of students' involvement in learning process so that the students get the material passively and less skilled in solving problems.

To overcome the problem that have been mention above will required a learning model that enable students to be active in learning process. One of the learning models is Problem Based Learning (PBL). PBL is one of learning models that is mainly designed to develop students' critical thinking skills, problem solving skills, intellectual skills, learning the roles of adults with experience through real and stimulated situations, and become independent learners [3]. The core of PBL model is the presentation of authentic and meaningful problem that become the basic of investigation and inquiry. PBL model is arranged based on real situation that avoid simple answer and invites competing solutions. The roles of teacher in PBL model involves presenting problem, asking question, making dialogue, helping students to find problem and facilitating learning process as in [21].

PBL steps according to Arend [4] are: (1) giving the orientation of the problems to students; (2) organizing the students to examine; (3) assisting independent and group investigation; (4) developing and present the artifacts and exhibit; (5) analyzing and evaluating the process of problem solving. PBL model can train students to use many concepts, principle and skill that have been learned to solve problems. However, it has weakness as it takes long time in learning process.

Constructive PBL model enables students to have high order thinking skills such as critical thinking, problem solving, and creative thinking (19). At the end of PBL learning, students can identify and solve problems with their own idea and ability, develop their creative thinking. One of high order thinking skills as in (8).

Conventional learning is learning process conventionally used by teachers in classroom teaching and learning process. Conventional learning involves: lecture method, question and answer method, task and discussion. Teacher centered learning is dominated by teacher that affects lack of students' involvement.

The implementation of problem solving in the learning process is important, besides trying to answer questions or solve problems, students are also motivated to work hard. In spite of developing problem-solving ability, this approach also emphasizes the achievement of high-level competencies such as critical, creative, and productive thinking [17].

Thinking critically is thinking rationally and reflectively that is focused on what is believed and done [10]. Critical thinking ability include: summarizing, explaining or reasoning, analyzing, synthesizing, generalizing, summarizing and evaluating or judging [16]. Some predictors such as age, gender, academic achievement, and education background affects PBL and critical thinking. Ennis [7] is a critical thinking indicators which consists of five major groups: (1) Elementary Clarification, (2) Basic Support, (3) Inference, (4) Advanced Clarification, (5) Strategy and Tactics.

Some researches conducting on the effect of PBL model on students' critical thinking and the result showed that PBL can enhance critical thinking ability [6,9,8,12].

Problem solving is one of high-level learning because students must have the ability to connect rules to achieve a solution [5]. Problem solving uses thinking processes to solve difficulties, collects facts about the difficulty and determines additional information that is needed [10]. Heller [13] creates problem solving steps in science through five stages: (1) visualize the problem, (2) describe the problem in physics description, (3) plan the solution, (4) execute the plan, (5) check and evaluate.

Research about the effect of PBL model on students' problem solving ability showed that students' problem solving ability of PBL group is better than Conventional group.

2. Method

This research was a quasi experimental research with two group pretest-posttest design. The population of this research was second semester of State Senior High School 1 class X academic year 2016/2017. The sample of this research were two classes that consisted of 70 students by using cluster random sampling technique. Class X MIA-1 as experimental class taught by PBL model that consisted of 34 students, class X MIA-2 as control class taught by conventional learning that consisted of 36 students. The instruments of the research were valid essay test of critical thinking ability consisted of 5 questions by using Enis indicator and 5 questions of problem solving ability by Heller, et.all. The data were analyzed by using t-test.

3. Result

At the beginning of the study, the two groups were given pretest aimed to determine the students ability in each group. The results of pretest and posttest of the experimental and control group in detail can be seen in Table 1. After applying different learning models, it was obtained posttest results in both groups. The results of the study by applying PBL (experimental group) and conventional method (control group) are as the following:

Table 1. Pretest and posttest Data

Variables	Groups	Pretest	Posttest	Gain
Critical Thinking Ability	Control	34.72	52.39	0.26
	Experimental	37.65	71.18	0,54
Problem-Solving Ability	Control	50.44	71.71	0.17
	Experimental	34.62	76.09	0.54

It can be seen in Table 1., it is obtained the gain of posttest score for critical thinking and problem-solving ability by applying PBL model.

Furthermore, the results obtained from the pretest and postes were analyzed to describe the items analysis of the critical thinking and problem-solving instruments that can be seen in Table 2 and Table 3.

Table 2. The Mean of Students' Posttest Answers For Each Item Analysis of Critical Thinking Ability in Control and Experiment Groups

No.	Critical Thinking Indicators	Mean Score of Item Analysis	
		Control	Experimental
1	Giving Simple Explanation	2.47	3.29
2	Building Basic Skills	2.05	2.68
3	Concluding	2.14	3.06
4	Making Further Explanation	2.19	3.09
5	Strategy and Tactics	1.67	2.22

Table 3. The Mean of Students' Posttest Answers For Each Item Analysis of Problem Solving Ability in Control and Experiment Groups

No.	Problem Solving Indicators	Mean Score of Item Analysis	
		Control	Experimental
1	visualize the problem	12.5	16.62
2	describe the problem in physics description	9.61	14.15
3	plan the solution	10.97	15.35
4	execute the plan	11	13.15
5	check and evaluate	9.61	12.44

Furthermore, the data from pretest and posttest were related to the gain of critical thinking and problem-solving abilities with normalized gain.

The category of normalized gain can be seen in Table 4.

Table 4. Normalized N-Gain Score

N-Gain Score	Category
0.00-0.20	very low
0.21-0.40	low
0.41-0.60	medium
0.61-0.80	high
0.81-1.00	very high

Gain category of control and experimental group of critical thinking ability can be seen in Figure 1.

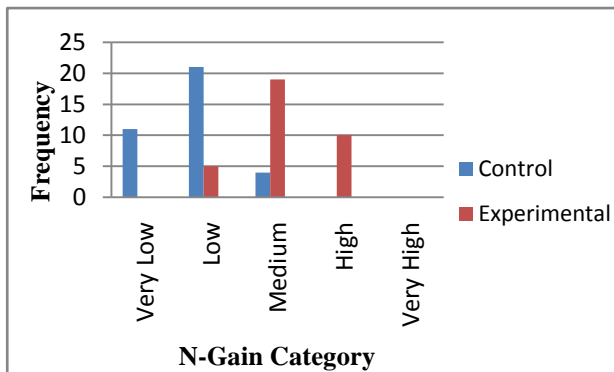


Figure 1. Gain Category of Students' Critical Thinking Ability in Control and Experimental Group

From the Figure above, it can be concluded that the gain of students' critical thinking ability of control class was in low level and experimental in medium level.

Gain category of students problem solving ability in control and experimental group can be seen in Figure 2.

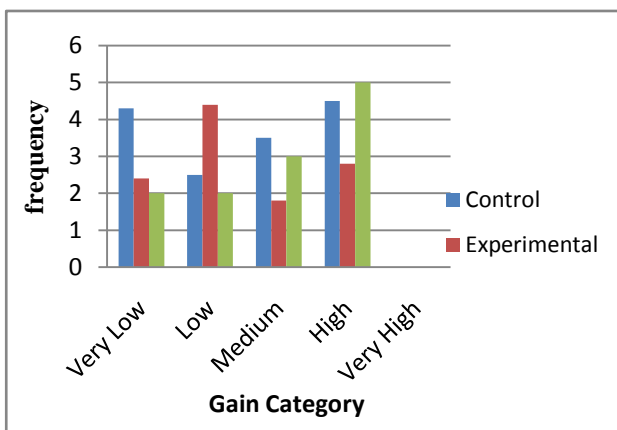


Figure 2. Gain Category of Students' Problem Solving Ability in Control and Experimental Group

From Figure 2, it can be concluded that the gain of students' problem solving ability of control group was in very low level and in medium level for experimental group.

After analyzing the gain, the next step was normality, homogeneity, and t-test. Normalized gain test used to know whether the sample came from normalized distributed population or not based on the gain of each student. Normalized gain test of control and experimental group used Kolmogorov-Smirnov with SPSS 17, level of significance 0.05 where the result of normality test can be seen in Table 5.

Table 5. Normality test of the gain of students' critical thinking ability in experimental and control group

Group	Kolmogorov-Smirnov ^a		
	Statistic	df	Sig.
Experimental	.100	34	.200*
Control	.075	36	.200*

Based on normality output in Table 5, significance level obtained from the gain of students' critical thinking in experimental and control group was higher than 0.05. It can be said that the gain of students' critical thinking in experimental and control group was in normal distribution.

Homogeneity test of two variance students' critical thinking pretest data of control and experimental group used Levene test SPSS 17.0 with significance level 0.05. After analyzing the data, the output can be seen in Table 6.

Table 6. Two Variance Homogeneity of Procedural Knowledge in Experimental and Control Group

Output	Levene Statistic	df1	df2	Significance
N-Gain Problem Solving Ability	1.672	1	68	0.200

Based on the output of homogeneity test with Levene in Table 6, the gain of problem solving ability obtained was 0.200. It showed that output significance level was higher than the level of significance 0.05. It can be concluded that students in control and experimental group came from populations that have the same variance, or both groups are homogeneous.

Hypothesis testing was done after feasibility data requirements were completed and fulfilled, then hypothesis was testing by using Independent Sample T-Test with SPSS 17. The data of critical thinking and problem solving ability obtained then calculated by using t test to see the difference average of posttest result of both sample groups.

The result of SPSS 17 calculation obtained output statistical posttest data of critical thinking using PBL model in conventional learning can be seen in Table 7.

Table 7. T-Test Gain of Critical Thinking Ability

Output	T	df	Significance (2-tailed)
Posttest Critical Thinking Posttest	10.229	68	0.000

Based on Table 7, it was obtained the significance level is 0.000, where the criteria were as the following:

- If the significance level is > 0.05, then H0 is accepted
- If the significance level is < 0.05, then H0 is rejected.

The significance level of 0.000 < 0.05, it can be said that H0 is rejected or Ha is accepted with the level of significance alpha 5%, thus it can be concluded that critical thinking skills of students taught by PBL model better than conventional learning.

The result of SPSS 17 calculation obtained output statistical posttest data of critical thinking ability using PBL model and conventional learning can be seen in Table 8.

Table 8. T-Test Gain of Problem Solving Ability

Output	T	df	Significance (2-tailed)
Posttest Problem Solving Ability	15.545	68	0.000

If the significance level is > 0.05 , then H_0 is accepted

- If the significance level is < 0.05 , then H_0 is rejected

The results of SPSS 17 obtained posttest statistical test of problem-solving ability of students using PBL model and problem-solving ability of conventional learning can be seen in [Table 8](#).

4. Research and Discussion

4.1. The Mean Gain of Students' Critical Thinking Ability Taught by PBL Model Is Better Than Conventional Learning.

The findings of this study showed that the mean gain of critical thinking ability of physics students taught by PBL model is better than conventional learning.

This better result occurred because the learning process with the PBL model encouraged students to actively participate in doing investigation of authentic problems. In conducting the investigation, the students discussed and communicated more in groups. The communication between group members were effective to get quick solutions for students to fulfill their ignorance about the topic being learned so that the process of critical thinking formed through the process of PBL model. While in the control group, because students can ask teacher directly, they choosed to ask teacher directly and did not discussed in groups effectively.

In addition, in the third phase of PBL model assisted independent and group investigation, the indicator of critical thinking ability was to build basic skills and hone the conclusion. During the process of independent and group investigation, critical thinking processes formed because students did observations of experiments conducted then recorded things gained during the experiment. After that the student must find a solution to the problem found while experimenting. This forced the students not only to think, but more than thinking of abstracts and complex ideas. While in the control group taught by conventional learning the students learned by listening more to the teacher's explanation in front of the class and did tasks or homework given by the teacher. It clearly showed that teacher dominates learning process so the teacher's role greatly affected students achievement.

Research conducted by Fakriyah [9] showed that students' critical thinking ability with PBL model can enhance students' thinking ability. This was in line with Ersoy [8] stated that the PBL model can enhance students' thinking ability. Eldy [6] showed that the problem solving ability can be enhanced by increasing the creative and critical thinking ability. Setyorini [21] stated that students' critical thinking enhanced significantly between experimental group taught by PBL models and control groups taught by DI model with lecture methods.

The enhancement of students' critical thinking ability in PBL model caused by the students being more careful in analyzing a problem, the ability to express ideas in groups and between groups. While in the control group, because they were free to ask teacher directly, the students prefer to ask teacher and do not discuss effectively in groups.

4.2. The Mean Gain of Students' Problem Solving Ability taught by PBL Model is Better Than Conventional Learning.

The findings of this study showed that the mean gain of students' problem solving ability in physics taught by PBL Model is better than students taught by Conventional Method.

Based on the analysis of each problem solving ability indicators obtained at the stage of understanding problems, interpreting, designing solutions,, implementing solutions and evaluationg solutions taught by the PBL model and conventional method had different results.

Firstly, understanding stage. At this stage, visualization of problems from words to visual representations, making a list of known and unknown variables, and identification of basic concepts. Students taught by PBL model understood more easily by combining the ability of the initial concept through the formulation of the problem to be developed to the actual problems with different understandings and lead to varied answers. It was different with students taught by conventional learning in which the interaction of learning tended to one way from teacher to student so that the student's initiative in understanding new things outside of teacher's presentation became difficult to develop.

Secondly, interpreting problem. At this stage, visual representation transformed into physics description by making free diagrams and choosing a coordinate system, or sketching. Students taught by PBL were more easily to interpret the problem by making diagram sketch to direct the physics problems faster because they had been accustomed to orient with problem in PBL model. It was different with students taught by conventional method where the ability to interpret problems was not accustomed during the learning process takes place.

Thirdly, planning phase of problem solving. Planning the solution by changing physics description into a mathematical representation. In PBL model at the stage of inquiry where students had been accustomed to get authentic data and process the data. This activity accustomed students to make complete planning from starting to finishing the investigation. It was different to students taught by conventional method where the abstract planning abilities without authentic investigation.

Fourthly, problem solving phase implemented the plan by performing mathematical operations. This activity was done to process data from the results of mathematical equations investigation through physics concept.

Fifthly, evaluating the solution. Evaluating solutions can be obtained by checking the completeness of answers, marks, units and grades by comparing or adjusting answers of physics concepts to constants, principles, laws, theories and general provisions that had been obtained through previous research.

The steps of problem-solving ability with Heller method were a series of systematic and integrated activities from start to finish. If in the early stages could not run well then automatically in the next stage would not run well. This was what distinguished the problem-solving ability and conventional learning.

The PBL model was the development of independent learners, the method required the active participation of students in problem-solving activities. Students actually had a sense of curiosity and a great desire to grow.

The PBL model used the exploration of the students' natural passions to give students specific directions to explore new fields effectively.

PBL model involved active, collaborative, and student-centered learning process that developed problem-solving and independent ability needed to face challenges of life and careers. Problem-based learning can be started by doing group work among students. Students investigate, find problems, then solve the problem under the guidance of the facilitator (teacher). Problem-based learning suggested students to find or determine relevant sources of knowledge.

This was in line with Sahyar's research [19] stated that problem-solving abilities of students with PBL models were better than conventional method. But, the research did not analyzed the gain but this research analyzed the students' gain to know the effect of PBL on problem solving ability.

The enhancement of problem solving ability of students in problem-based learning model caused by students to be more creative to have a high sense of curiosity because during the learning process students were presented an authentic problem. This was in line with Sahyar's research [18] that curiosity would improve students' problem solving ability in physics. This was because students who had above average intelligence would assume that a problem as an opportunity to achieve goals, students would not easily give up until students were able to solve the problem given. But, his research did not analyzed the students's gain but this research analyzed students' gain to know the effect of PBL model on problem-solving ability.

Adeyemo [1] concluded that despite the different ability of students, but when treated with PBL model then students enhanced in problem-solving abilities. Folashade [11] suggested that physics students with low-level skills taught with learning-based problems were significantly better than students taught by conventional models. In line with Santyasa's research [20] explained that there was an interactive influence between model and learning setting on conceptual comprehension and problem-solving abilities. The development of understanding and problem solving abilities of physics for high school students could be built in synergy between the conceptual change model and the group investigation setting.

5. Conclusion

Based on the result of research, it is obtained that the gain of critical thinking ability of physics of student using PBL model is in medium category and gain critical thinking ability of physics students using conventional

learning that is in low category. While the gain of problem solving ability of physics student using PBL model is in medium category and gain ability of problem solving physics student using conventional learning that is in very low category. This shows that the gain of students' critical thinking ability physics using PBL learning model is better than the students' critical thinking ability using conventional learning. Gain students' problem solving skills using PBL learning model is better than the students' physics problem solving ability using conventional learning. This shows that there is influence of PBL model to students' critical thinking ability and students' physics problem solving ability.

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