**Journal of Primary Education**
10 (1) (2021) : 105 – 112

https://journal.unnes.ac.id/sju/index.php/jpe/article/view/34301

# The Effectiveness of Problem Based Learning (PBL) with Open-Ended Approach on Problem Solving Ability

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## Article Info

*History Articles*
Received:
August 2019
Accepted:
September 2019
Published:
April 2021

*Keywords:*
*open ended,*
*PBL,*
*problem solving*

DOI
https://doi.org/10.15294/jpe.v10i1.34301

## Abstract

This study has the purpose of analyzing the effectiveness of the Problem Based Learning (PBL) model with the Open-Ended approach on students' problem-solving abilities. This type of study was an experimental research with a non-equivalent pre-test – post-test control group design. The population of the study was grade IV students of Elementary School in Cluster of Jenderal Sudirman, Kebonagung District, Demak Regency in 2018/2019. Samples were taken by using a random sampling technique. Problem-solving ability as a dependent variable. And the Open-Ended approach as an independent variable. The method was used as an essay test item. The data analysis techniques were using Validity, Reliability, Difficulty test, Normality test, Homogeneity test, t-test, and N-gain test. Problem-solving ability can be improved by applying the PBL model with the open-ended approach. This can be shown based on the results of N-gain test is the average value of an experimental group is higher than the control group (0.7029 > 0.5118). The average N-Gain problem-solving ability of students taught using the PBL model with Open-Ended approach is higher than average N-Gain problem-solving ability of students taught using the PBL model.



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p-ISSN 2252-6404
e-ISSN 2502-4515

## INTRODUCTION

Mathematics is considered as a difficult subject for some students, and learning mathematics usually requires high concentration. At present, there are still many students who have difficulty learning mathematics (Leonard, and Supardi, 2010). However, mathematics has an important role for students, if, in the learning process, the delivery of material is conveyed by the use of model or media, which is following the material taught.

One of the problems that arise in the learning process in mathematics is the low problem-solving ability of students. Problem-solving ability is an important aspect for students to have as stated (Nadhifah, and Afriansyah, 2016) Mathematics learning in schools must be able to prepare students to have mathematical problem solving and mathematical communication skills, as a provision to face the challenges of development and change of era.

Based on the result of PISA 2009, the quality of Indonesia's mathematics learning ranks at 68th out of 74 countries. It is the same as in the Trends in International Mathematics and Science Study (TIMSS) test, which is held every four years, in the fields of mathematics and science. The test results also show the ability of Indonesian students is below the international average score. Based on the 2011 TIMSS Results in the quality of Indonesia's mathematics learning ranks 38$^{th}$ out of 42 countries (Setiawan, and Harta, 2014). The results of TIMSS 2015, which was just published last December 2016, show Indonesian students' achievements in mathematics ranked 46 out of 51 countries with a score of 397. Indonesian students master routine questions, simple computing, and measure knowledge of facts that have daily contexts. Therefore, it is necessary to strengthen the ability to integrate information, provide conclusions, and generalize knowledge to other matters (Rahmawati, 2016).

The results of interviews with educators and observations in grade IV SD Negeri Mangunan Lor and SD Negeri Klampoklor, the PBL learning model is seen as an efficient model used in mathematics, particularly for problem-solving strategies. In applying the PBL learning model, students were active in the learning, and however, when given questions that are different from the example, students found difficulty in solving them. In solving questions, students were accustomed to only fixing on one alternative answer like in a textbook. This can cause students not to be able to develop the ability to solve various problems.

According to the learning theory proposed by Gagne as cited by Hertiavi, Langlang, and Khanafiyah (2010) states that high intellectual skills, including mathematical reasoning, can be trained and developed through problem-solving or problem-solving. According to Gagn, problem-solving is seen as a process to find a combination of several rules that can be applied to overcome new situations that have never been encountered by students.

Problem-solving is not only a form of an ability to apply the rules that have been mastered through learning activities, but more than that is a process to get a set of rules at a higher level. Gagne added that if someone has obtained a combination of rules that can be operated according to the situation at hand, he not only solves the problem but also manages to find something new. Something that is meant is a strategy that allows a person to increase independence in thinking (Wena, 2009).

Problem-solving is a process or individual effort to resolve an unclear answer (Siswono, 2008). The ability to solve problems is a skill that involves the process of analyzing, interpreting, reasoning, predicting, evaluating, and reflecting (Riau, and Junaedi, 2017).

According to Cooney as quoted by Ulvah, and Afriansyah (2016) argues that problem-solving abilities help students think analytically in making decisions in daily life and help improve critical thinking skills in dealing with new situations. That way, the mathematical problem-solving abilities possessed by students when studying mathematics in school will be a provision for them to face their lives in the future in solving various problems they face in real life.

Based on the above problems, it is necessary to make changes in learning so that educators can optimally facilitate students in learning and solving problems. The ability to solve mathematical problems requires the activeness of students in learning. The tendency of the learning model to shift from teacher-centered to student-centered, a change from learning theory and assessment from behavioristic models to constructivist models. Learning models that usually tend to be linear, static, and mechanistic need to be changed towards innovative learning because the learning model is a component that also determines the success of learning. It is in agreement with Djamarah, and Zain (2010) which explains that the learning model is one component that also determines the success of learning. Learning is said to be successful if it can achieve the stated goals.

The selection of the right model in learning is one of the challenges that must be faced by educators. The learning model is expected to motivate students in learning, understanding concepts, and solving problems. Learning activities that can provide opportunities for students to exchange opinions, work together, interact actively with educators, and respond to the thoughts of other friends, make students able to remember longer the concepts of a material that can apply them in solving problems both in the learning or real life.

Constructivism learning theory reveals that learning is a process of forming knowledge. Constructivism theory emphasizes the need for students to investigate their environment and personally build their knowledge. Learners must be active in learning activities, active in thinking, conceptualizing, and giving meaning to things that are learned.

The thing that most determines the manifestation of learning symptoms is the students' learning intentions themselves. That knowledge will be meaningful if sought and discovered by students themselves. It can be said that the nature of learning control is entirely in the students. In constructivism theory, the role of an educator is to make learning run smoothly and to encourage students to develop learning itself.

That knowledge will be meaningful when students seek and find it themselves. It can be said that the nature of learning control is entirely in the students themselves (Abdurrozak, Jayadinata, and Isrok'atun, 2016). The problem-solving ability of students can be resolved by applying the PBL model in learning. According to Ula, Supardi, and Sulhadi (2018) PBL is one of the innovative learning models that is applied to develop students' ability in solving a problem.

PBL models are student-centered, which enable students to be active in the learning process (Saleem, Zain, Mohd, & Salmiza, 2014). PBL allows students to develop adaptability and change methods to new situations (Vendiagrys, Junaedi, and Masrukan, 2015).

To further improve the problem-solving ability of the PBL learning model, it seems better to combine it using the Open-Ended approach. According to Sakti, Hartanto, Dharmayana (2017) students' way of thinking can be improved by Open-Ended learning. According to (Nur, 2017) problems that are formulated to have multiple correct answers are called incomplete problems or also called Open-Ended Problems or open problems. Students who are exposed to the Open-Ended Problem, the main goal is not to get an answer but rather to emphasize how to arrive at an answer. Thus not only one approach or method for getting answers, but there are several or many ways to find answers to existing problems.

Agree with Fitriati, and Edema (2016) the Open-ended approach is an approach that uses mathematical problems that are formulated in such a way that has multiple or diverse solutions. Open-Ended Learning is more concerned with the process of the product that will form a mindset and a variety of thinking so that it can be used to improve students' mathematical problem-solving abilities. The use of open-ended problems in learning is beneficial for students to solve problems in learning and everyday life (Suwandi, Hasnunidah, and Marpaung, 2016).

This study aimed to determine the effectiveness of the PBL model with an Open-Ended approach to problem-solving skills.

## METHODS

The topic in this study is the Alliance Factor, the Biggest Alliance Factor (FPB) and Multiples Factor, the Smallest Multiplication Factor (FPK). The study design was a pre-test – post-test nonequivalent control group design. The sampling technique in this study was carried out using simple random sampling in which the sampling of members of the population was carried out randomly in groups without regard to strata in the population (Sugiyono, 2016). In this design, there were two groups chosen at random, one group as a control group and one group as an experimental group. A control group is a group with the implementation of the PBL model. An experimental group is a group with the implementation of the PBL model with the Open-Ended approach in the learning.

In this study, there were two variables used, the independent variable and the dependent variable. The independent variable (X) in this study was a PBL learning model within the open-Ended approach. The dependent variable (Y) in this study was the problem-solving ability. The technique used in this study was a test technique with a 5-item test item of the essay. The data analysis techniques were used initial data analysis, prerequisite analysis of final data, and hypothesis analysis of final data. The initial data analysis techniques were: Initial data of normality test, initial data of homogeneity test, initial data of average similarity test. Meanwhile, the analysis of the prerequisites of the final data was: normality test, homogeneity test. Hypothesis analysis of the final data was: the completeness test of learning, the average difference test of the problem-solving ability of students, the improvement test of problem-solving abilities.

## RESULTS AND DISCUSSION

Based on the results of the research and data analysis, in the experimental group, learning by using the PBL model with the Open-Ended approach makes students enthusiastic in participating in learning and challenged to know how to understand problems, plan problem solving, try various strategies or alternative solutions that have been planned, to find solutions of the problems faced in the question given by the teacher. Thus, the experimental group students are accustomed to mathematical problem problems and accustomed to solving problems through ideas independently, systematically with various alternative answers.

In the control group, learning by using the PBL model does not have much influence on students. Learners look passive and have difficulty in completing the problem description given by the teacher. Learners are only fixated on one alternative problem solving as in the handbook. As a result, students in the control group do not like problem-based questions in learning. Students prefer questions that have the form and resolution as examples in the book or explained by the teacher.

The differences in the learning conditions result in differences in the acquisition of students' mathematical problem-solving abilities in the control group and the experimental group. The results showed the experimental group with the application of PBL with the Open-Ended approach obtained a higher average than the control group applying the PBL learning model without the Open-Ended approach.

Based on the hypothesis test of the completeness of the students' problem-solving abilities, in the control group obtained results $z_{0.5}$ or $z_{table}$ -1.645. Because $z_{value} > z_{table}$ or -0,678 > -1.645 then $H_0$ is rejected. Therefore, it can be concluded that the proportion of control group students said n the learning with the PBL model that meet the minimum completeness criteria that are 70 reaches more than 75%.

Result of the average score of the student's problem-solving ability can be seen on Table 1.

**Table 1**. Post-test Independent Sample Test

| | Levene's test for equality of variances | | t-test for equality of means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | F | Sig. | t | df | Sig. | Mean difference | Std. error deviation | 95% Confidence interval of the difference | |
| | | | | | | | | Lower | Upper |
| Equal variances assumed | 3.556 | .067 | -1.750 | 37 | .088 | -9.438 | 5.393 | -20.365 | 1.488 |
| Equal variances not assumed | | | -1.842 | 36.277 | .074 | -9.438 | 5.123 | -19.826 | .94985 |

Based on Table 1, the students' problem-solving ability obtained the result of the sig. (2-tailed) Value was 0.088 in the post-test data. Since 0.088 and 0.074 > 0.05, $H_0$ is accepted, which means that the average problem-solving ability of students taught using the PBL model is the same as the average problem-solving ability of students taught using the PBL with the Open-Ended approach.

Based on Table 1, the average value of the Means Difference is the same, and then it can be seen in Table 2.

**Table 2**. Result of Post-test Group

| Grade | N | Mean | Std. deviation | Std. error mean |
|---|---|---|---|---|
| Control | 22 | 74.0909 | 19.18806 | 4.09091 |
| Experiment | 17 | 83.5294 | 12.71868 | 3.08473 |

Based on table 2, it can be seen that the average post-test value for the control group is 74.0909 and the experimental group is 83.5294. Since the average score of the experimental group is higher than the average score of the control group, therefore, it can be concluded that the average problem-solving ability of students taught using the PBL model with the Open-Ended approach is higher than the average problem-solving ability of students who are taught using the PBL model.

The results of the improvement of students' problem-solving abilities using the t-test can be seen in Table 3.

**Table 3**. Paired Sample Test Paired Differences

| | t | df | Sig. | Mean difference | Std. error deviation | Std. error mean | 95% confidence | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lower | Upper |
| Pre-experimen Post-experiment | -13.876 | 16 | .000 | -33.529 | 9.96317 | 2.41642 | -38.652 | -28.406 |

The t-test results are presented in Table 3 paired samples test. Pair is the result of the pre-test and post-test for the experimental group.

Based on Table 3 paired samples test, shows the value of sig. = 0.000 for a pair. Since 0.000 < 0.05, then $H_0$ is rejected, it can be assumed that there are significant differences in the average pre-test and post-test ability of students in solving the problem. Since there are significant differences, then it can be seen in Table 4 paired sample statistics.

**Table 4**. Paired Sample Statistic

| Grade | N | Mean | Std. deviation | Std. error mean |
|---|---|---|---|---|
| Pre-experimen | 50.0000 | 17 | 16.20185 | 3.92953 |
| Post-experiment | 83.5294 | 17 | 12.71868 | 3.08473 |

Based on Table 4, it is found that the average pre-test score for the experimental group was 50.0000, and the average score of post-test for the experimental group was 83.5294. Since the average post-test score is higher than the average pre-test, it can be concluded that there is an influence on the implementation of the PBL model with the Open-Ended approach in the form of improvement of the students' problem-solving abilities.

The effectiveness of the PBL model with the Open-Ended approach on the problem-

solving abilities of students, was tested using the N-gain as can be seen in Table 5.

**Tabel 5**. Independent Sample Test

| | Levene's test for equality of variances | | t-test for equality of means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | F | Sig. | t | df | Sig. | Mean difference | Std. error deviation | 95% confidence Lower | 95% confidence Upper |
| Equal variances assumed | 1.559 | .220 | -2.102 | 37 | .042 | -.19112 | .09092 | -.37534 | -.00691 |
| Equal variances not assumed | | | -2.220 | 35.987 | .033 | -.19112 | .08610 | -.36574 | -.01650 |

Based on Table 5, the results of the N-gain test of the problem-solving ability of the students above, it can be seen that the value of sig. (2-tailed) produced 0.042 (0.042 < 0.05), then $H_0$ is rejected, which means that the average

N-gain of the problem-solving ability of students taught using the PBL model is not the same as average N-Gain of students' problem-solving abilities taught using the PBL model with Open-Ended approach.

Since there are the same in the means difference in Table 5, then it can be seen in Table 6.

**Table 6**. N-gain Group Statistic

| | N | Mean | Std. deviation | Std. error mean |
|---|---|---|---|---|
| Control | 22 | .5118 | .32576 | .06945 |
| Experiment | 17 | .7029 | .20981 | .05089 |

Based on Table 6, it is found that the average value of N-gain for the control group is 0.5118 and the experimental group is 0.7029.

The improvement of problem-solving ability is strengthened by the research of Noviana (2018) using the Open-Ended learning model in grade VIII students of Public Junior High School 1 Candipuro, South Lampung, that there is an influence on the application of the Open-Ended learning model to the mathematical problem-solving abilities of grade VIII students at Public Junior High School 1 Candipuro, South Lampung 2017/2018 academic year. The average acquisition of students' mathematical problem-solving abilities using the Open-Ended learning model is higher than the average mathematical problem-solving abilities of students who use conventional learning that is 74.19 > 42.5.

Problem-solving ability is an important component that must be had by students to build a concept of subject matter and mathematical thinking. (Kumar, and Clark, 2016) also found that "mathematical problem solving is central to mathematics learning. It involves the acquisition and application of mathematics concepts and skills in a wide range of situations, including non-routine, open-ended, and real-world problems. This shows that problem-solving has a very important role in learning mathematics. Problem-solving must apply broad concepts and skills, including non-routine, open-ended problems, and problems that are relevant to the real condition of life.

In the learning using the Open-Ended approach, students are not only required to find solutions to the problems given but also provide arguments about the answers and explain how students can arrive at these answers (Ulfa, and Asriana, 2018). With not only one way to get answers, but several that can be used. This learning also provides an opportunity for students to gain knowledge, experience discovering, recognizing, and solving problems in several ways in interpreting the problem in the problem-solving process carried out.

## CONCLUSION

The conclusion of this research stated that the implementation of the PBL model with an Open-Ended approach is effective on students' problem-solving abilities. This is indicated by the percentage of minimum completeness criteria (KKM) of the control and experimental groups which is 75%, with an average value of the experimental group higher than the control group; the average value of the problem-solving

ability of students of the experimental group is higher than the control group; the results of the t-test increase the average ability of students to solve the problem by applying the PBL model with the Open-Ended approach, the average post-test of the experimental group is higher than the average pre-test of the experimental group; and the results of the N-gain model of PBL with the Open-Ended approach is more effective than the PBL model.

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