Implementation of Problem Based Learning to Train Physics Students’ Problem Solving Skills

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Abstract. Problem solving skills (PSS) are the skills needed to face the challenges of the industrial revolution 4.0, which need to be developed through the learning process, and are still a challenge for teachers today. This study aims to determine the effect of the implementation of problem-based learning (PBL) in practicing students' problem solving abilities on material momentum and impulses. The research utilised a pre-experimental design with one-group pretest-posttest paradigm. The sample in this study consisted of 3 groups: one experimental group and two replication groups. The results showed that the implementation of PBL affected the problem solving abilities of students in the experimental and replication groups. The three groups experienced a different increase of PSS due to several factors, namely the implementation of learning, the existence of different student intelligence and student activities during learning.

1. Introduction

The Industrial Revolution 4.0 is a formidable challenge for the fields of education to be able to create competent graduates, who are ready to compete in a globalized world [1]. Education must be able to develop students having communication skills, collaboration, critical thinking, problem solving and literacy [2]. Physics is one of the subjects that is influential in growing problem solving skills to face the industrial revolution 4.0. This can be seen from the purpose of learning physics at school that is preparing individuals to have life skills as individuals and citizens who can think critically, analytically, logically, creatively, be able to solve problems and have the skills to communicate, be independent and have a sense of responsibility towards social life in community [3].

Problem solving skill (PSS) is a human activity which combines concepts and rules obtained previously and not as an ability that is obtained suddenly, but must be trained continuously [4]. Therefore, it can be stated that PSS is the main skill that develops students' ability to think of situations, problems and problems in new and different ways; and also to deal with it using creative, systematic and analytic strategies [5]. Stages of PSS include (a) understanding the problem; (b) devising a plan; (c) carrying out the plan; and (d) looking back [6]. The problem given or examined should be an authentic daily activity problem, meaningful, relevant, and related material that is being or has been taught [7]. Most students consider physics as a problem, so the problem-based learning (PBL) model is very appropriate in learning physics. In addition, PBL is a type of learning model suggested by the 2013 curriculum because it is relevant to the scientific approach [8].
PBL model is designed by providing problems that require students to gain important knowledge so as to make students proficient in solving problems, and have their own learning strategies and have the ability to participate in teams [9]. According to Arends [10] with the implementation of problem-based learning so students can have inquiry skills, problem solving skills, social skills and skills to actively build their own knowledge. Teachers during learning must be able to design and manage the learning process using PBL models [11], as well as the teacher's role in raising problems, facilitating investigation and discussion.

Based on the results of previous studies by Makmur [12], it was found that the problem-based learning model was better than the application of direct learning. Similarly, a previous study by Retno [13] found that there was an influence of the interaction of PBL models with problem solving abilities and cognitive learning outcomes. According to Argaw [14] getting research results that the problem solving ability of students who obtain PBL increases significantly. Problems that are used in PBL models are authentic problems or problems that arise in the environment.

2. Method
The participants of the research was students of the tenth grade at a public senior high school in Surabaya, Indonesia. The participants were classified into three groups, consisting of one experiment group (X-MIA 4) and two replication groups (X MIA-5 and X MIA-6). This study uses a quantitative pre-experimental approach with one group pre-test post-test design. The following Table 1 describes the detail of the research design:

| Table 1. Pre-test and Post-test Design. |
|----------------------------------------|
| Group | Pre-test | Treatment | Post-test |
|-------|----------|-----------|-----------|
| Experiment | O₁ | Using PBL | O₂ |
| Replication I | O₁ | Using PBL | O₂ |
| Replication II | O₁ | Using PBL | O₂ |

The data analysis used paired t-test and n-gain scores to find out to what extent the improvement in students' problem solving skills (PSS) after obtaining a problem-based learning treatment. PSS includes the ability to understanding the problem, devising a plan, carrying out the plan, and looking back.

3. Results and Discussion
This study used a paired $t$ test and obtained a score to analyze the results. Before the paired $t$ test was done, the researchers checked the normality and homogeneity of the data at first. Test for normality and homogeneity as a prerequisite to find out whether the sample obtained was normally distributed and whether the sample is from a homogeneous population [15].

| Table 2. The normality test. |
|-----------------------------|
| Group   | Number of Students | Pre-test | Post-test | Conclusion |
|---------|-------------------|----------|-----------|------------|
|         |                   | $X^2_{count}$ | $X^2_{table}$ | $X^2_{count}$ | $X^2_{table}$ |       |
| Experiment | 33   | 4.21       | 5.45      | Normal     |
| Replication I | 33   | 6.75       | 11.07     | 4.02       | 11.07       | Normal |
| Replication II | 33   | 7.75       | 3.17      |            |            |        |
Table 3. The homogeneity test.

| Group            | Number of Students | $X^2_{count}$ Pre-test | $X^2_{count}$ Post-test | $X^2_{table}$ | Conclusion   |
|------------------|--------------------|------------------------|-------------------------|---------------|--------------|
| Experiment       | 33                 |                        |                         |               | Homogeneous  |
| Replication I    | 33                 | 1.46                   | 0.52                    | 5.99          |              |
| Replication II   | 33                 |                        |                         |               |              |

In the result of the normality test (Table 2) showed that all three groups were normally distributed because $X^2_{count} < X^2_{table}$. So $H_0$ was accepted with a confidence level of 0.05 (for the educational field). For the homogeneity test of variance (Table 3) indicated that the sample was homogeneous because $X^2_{count}$ of 1.46 in pre-test value and 0.52 in post-test whereas for $X^2_{table}$ of 5.99. Then $X^2_{count} < X^2_{table}$ and $H_0$ was accepted with a significant level of 0.05. Based on the two tests, it can be passed on to the next test, namely the paired t test to find out whether there were any differences in the average results of the study before and after give treatments.

Table 4. The result of t-test.

| Group            | $t_{count}$ | $t_{table}$ | Conclusion   |
|------------------|-------------|-------------|--------------|
| Experiment       | 68.86       |             |              |
| Replication I    | 45.71       | 1.69        | Significant Different |
| Replication II   | 33.03       |             |              |

Table 4 presents the results of the paired t test analysis between the experiment group and the replication groups. The three groups showed that $H_0$ was rejected ($t_{count} \geq t_{table}$) which meant that there was a significant difference in the problem solving abilities of the experimental group and replication significantly on the material of momentum and impulses after the implementation of the problem based learning model.

Table 5. The result of gain score.

| Group            | $<g>$ | Category |
|------------------|-------|----------|
| Experiment       | 0.62  | Medium   |
| Replication I    | 0.61  | Medium   |
| Replication II   | 0.65  | Medium   |

Based on Table 5, the acquisition score for the experimental group was 0.62, the replication group I was 0.61, and the replication group II was 0.65. All three groups were in the medium category. These results were consistent with research of Rohana [16] which stated that the application of problem-based learning has a significant effect on improving students' physics problem solving abilities with an increase in being in the medium category.
Based on Figure 1, students in all three groups experienced an increase in the ability to solve different problems at the four stages of problem solving. In the three groups, the lowest pre-test scores were at the UP stage, this was because students are not accustomed to analyzing and evaluating the accuracy of the procedures applied with the results obtained in solving problem solving problems. Whereas at the CP stage the experimental group obtained the highest average value of the two replication groups. This condition could be explained that students are quite capable of carrying out the steps that have been made previously to get the solution of a problem. In the replication group I and group II the UP stage obtained the highest average score, this is because students are able to understand the problem by formulating things that are known, things that are asked in a more operational form.

In the three groups the highest average post-test scores were found at the UP stage in all three groups. This is because students after being treated in the form of the application of problem-based learning, students are better able to understand existing problems by formulating things that are known, things that are asked in a more operational form. This is supported by activity data that has a high activity value which proves that there is a linear relationship between learning activities and student learning outcomes [17].

The pre-test and post-test questions are in the form of authentic, meaningful, relevant and problem-solving problem solving in students' daily lives. Here is one example of a problem with a problem indicator that is deciding the solution of problems related to momentum and impulses using the problem solving indicator.

![Figure 1](image-url)
In addition to the problem solving problem, student answer sheets were also made tables of stages of problem solving which included stages in understanding the problem, devising a plan, carrying out the plan, and looking back. Next step is one of the answers of students from the experimental group in answering problem solving questions.
The results of increasing the problem solving ability of the three groups have different n-gain values but not too far, this is due to differences in problem solving abilities possessed by students in each group that can affect the pre-test and post-test scores. This difference can be caused by several factors, one of which is the implementation of learning, the existence of different student intelligence and student activities during learning.

First of the implementation of the learning process carried out by the teacher. The implementation of learning is part of the process that has a contribution to the achievement of learning outcomes, but we cannot generalize the results of each student’s achievement. Improving problem solving skills depends on the student’s understanding of speed. When the learning process is good, then the students’ problem solving abilities should also be good. Secondly, the difference in students’ different intelligence can be seen from the students’ pre-test and post-test scores. While the third of the student activities carried out by the teacher. Students who have moderate n-gain scores tend to have lower grades in learning activities.

In this research, problem-based learning can train students’ problem solving skills on material momentum and impulses. One reason is by applying the problem-based learning model students are skilled in solving problems, both related to academic problems and everyday life. These results are also in line with research conducted by previous researcher, such as [11], [18-19] signaled that teachers can apply problem-based learning to improve students’ creative thinking skills, problem solving skills, and learning outcomes.

4. Conclusion
The results of this study indicate that there are significant differences between the experimental and replication groups after receiving treatment in the form of application of problem based learning. The increase in the three groups was in the medium category, namely the experimental group experienced an increase in problem solving with a gain score of 0.62, the replication group I by 0.61, and the replication group II by 0.65. The three groups experienced a different increase due to the implementation of learning, the existence of different student intelligence and student activities during learning.

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