Influence of physics problem-solving ability through the project based learning towards vocational high school students’ learning outcomes

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Abstract. Physics, an adaptive subject in SMK, is the basis and prerequisite for productive and applicable material, so it needs to be emphasized on problem solving approaches. This study aimed to determine the influence of learning methods based on the problem solving ability on learning outcomes. The intended learning outcomes are cognitive learning outcomes and the learning method used is project based learning. The type of research was quasi-experiment. The population in this study were the 10th grade students of SMK Negeri 5 Surakarta in the 2018/2019 academic year which consisted of 7 majors with 22 classes. The sample of this study were 2 classes from the Mechanical Engineering department, each of which amounted to 35 students. The instrument used in this study consist of 20 multiple choice questions and 5 essay question of the Physics problem solving abilities. Data were analysed using normality test, homogeneity test and hypothesis testing with analysis of variance techniques (ANOVA). Based on the results of the study it was found that the influence of the interaction between learning method and problem solving ability on cognitive learning outcomes showed sig 0.043 ≤ 0.05. It can thus be concluded that there was an influence of the interaction of the learning model with the problem solving ability with cognitive learning outcomes. Therefore project based learning methods can be used as an alternative for teachers in carrying out their learning to create an active learning atmosphere and enhance students’ ability to understand physics problems.

1. Introduction

Physics lessons, part of adaptive subjects in vocational schools, are the basis and prerequisites for productive and applicable material so that it requires more understanding than memorization. By learning physics, vocational students are expected to be able to apply physics concepts in the field to be occupied. During learning, students are actively involved as activities to build ideas in solving problems. Seeing the focus of vocational students’ graduates, mastery of competency and thinking skills need to be developed optimally and maturely.

Oriented to the achievement of skills competencies and thinking abilities, physics learning has a goal including understanding, developing knowledge and analytical skills towards the surrounding environment. Students learning physics is not limited to mastering concepts but also applying concepts
in solving physics problems. However, there is still a lot of classroom learning that tends to emphasize mastery of concepts and override problem solving abilities [1].

Based on the results of questionnaires distributed to students majoring in the Mechanical Engineering at the 5th Surakarta State Vocational High School, it can be seen that physics lessons are more unpopular with students because physics is a difficult subject. The difficulty is caused by students who are passive and the implementation of physics learning which tends to focus on the teacher without involving students, consequently students are less motivated to think about physics learning material. The resulting learning outcomes become less satisfying because learning is still centered on the teacher so students are less actively participating during the learning process. As a result, students become less creative in solving problems, less than optimal in collaboration between group members and less participating in discussions. Therefore, thinking ability becomes one of the things that needs to be improved. Thinking ability can be said to increase if students are able to think creatively, be critical and able to solve problems. Problem solving ability is included as part of high-level thinking skills, but there are still many students who are less able to solve problems [2]. Physics learning which is packed with problem solving learning methods has an impact on mastery of students' physics concepts [3].

To increase students' inability to solve problems, it is necessary to provide learning that involves students actively. Therefore, it is important for physics teachers to use methods that can make students active, because the learning method is one of the factors that determine the success of teaching and helps students and teachers in delivering subject matter. Several previous studies used the project based learning (PjBL) method in physics learning. The results of the study show that applying project-based learning makes the learning environment more active, better learning experiences and increased problem-solving abilities [4]. Similar things revealed that project-based learning can improve students' ability in solving problems also found in other studies [5].

Based on the problems that arise in the majority of SMK Negeri 5 students, it is necessary to have a learning method that can involve students actively. Project-based learning method is chosen because the steps (syntax) of learning can guide students to discover new concepts and improve problem-solving ability so that student learning outcomes increase.

1.1. Problem solving ability
Problem solving ability is solving the target with the smallest possible negative impact, both for the individual concerned and with other individual objects [3]. Iklima [6] explains that some experts argue that problem solving is the ability of individuals to connect between concepts or knowledge possessed by existing reality. To solve problems, it is necessary to have initial conditions or initial abilities that students have so students can connect with new material to solve new problems. Uno [7] states that solving problems is answering a question where the method to find a solution to the question is not known first. Problem solving can also be interpreted as finding steps to overcome existing gaps. Whereas problem solving activities are human activities in applying the concepts and rules previously obtained.

Based on the description, it can be understood that problem solving ability is a process in which individuals try to determine a problem solution effectively by involving cognitive strategies. The stages of problem solving ability in this study were adapted from Polya [8] namely: (1) Understanding the problem, (2) Planning the solution, (3) Resolving the problem, and (4) Re-examining the results obtained (looking back). The four stages of problem solving from Polya are a very important unit to develop. One way to develop students' ability to solve problems is through providing strategies that vary from one problem to another.

1.2. Project based learning method
Problem-based learning is an effective educational approach that focuses on creative thinking, problem solving, and interaction between students and their peers to create and use new knowledge. Particularly this is done in the context of active learning, scientific dialogue with active supervisors as researchers [9]. The steps (syntax) for implementing project-based learning as developed by The George Lucas Educational Foundation [10] are shown in table 1.
Table 1. Project based learning syntax.

| Stage                                | Description                                                                                                                                 |
|--------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| Start with the essential question    | The teacher provides a stimulus, for example providing with video shows that are interesting or presenting forms of real problems around them. |
| Design a plan for the project        | Students work in groups and collaborate with the teacher to make a project plan.                                                           |
| Create a schedule                    | Teachers and students collaborate to arrange an activity schedule in completing the project.                                                 |
| Monitor the students and the progress of the project | The teacher is responsible for monitoring the activities of students while completing the project.                                      |
| Assess the outcome                   | The teacher tests / evaluates the learning process and results.                                                                          |
| Evaluate the experience              | Teachers and students reflect on the activities and results of the projects that have been carried out.                                    |

Project-based learning involves students actively in building their own knowledge and involving group work to produce a project as an application of the concepts that have been obtained. Learning using this method makes students accustomed to discovering their own physics concepts through projects provided by constructing knowledge in students [11]. According to Priyatna [12] some of the advantages of project-based learning include: (a) Increased motivation, (b) Increased problem-solving ability, (c) Improved library research skills, (d) Increased collaboration, and (e) Increased resource-management skills. The selection of learning methods is expected to overcome various problems experienced by students during the learning process, so that student learning outcomes will increase.

1.3. Learning outcomes
According to Azwar [13], learning outcomes are mastery of knowledge or skills developed by subjects which are usually indicated by the value of the test or the number of values given by the teacher. Sudjana [14] suggests that learning outcomes are evidence of the success achieved by someone. Thus, learning outcomes are the maximum results achieved by someone after carrying out learning efforts. Still according to Sudjana [14], the assessment of learning outcomes is the process of giving value to learning outcomes achieved by students with certain criteria. This understanding implies that the object being assessed is the result of student learning from the cognitive, affective, and psychomotor domains.

To find out the results of learning it is necessary to use a tool to measure learning outcomes. Usually using description test, multiple choice, and matchmaking questions. There are two factors that influence learning outcomes, namely internal and external factors. Internal factors, are factors that originate in the individuals include motivation, interest, talent, self-concept, study habits. External factors are factors outside of individuals distinguished by social and non-social environmental factors.

2. Methods
This research was quasi-experimental using post-only control design. The population used in this study was the 10th grade students of SMK Negeri 5 Surakarta in the 2018/2019 academic year consisting of 7 majors with 22 classes. The sample in this study was taken using a technique using cluster random sampling. The cluster random sampling was conducted to obtain a sample of 2 classes, namely class X TM C as the experimental group and class X TM D as a control group with each group consisted of 35 students.
The instrument used in this study is the posttest in the form of 20 multiple choice and 5 essay type questions of the physics problem solving abilities. The instrument of this study was analyzed for validity and reliability. Posttest was used for cognitive assessment of students while the problem solving ability test is to find out the grouping of students with high and low problem solving abilities. The indicator studied was the ability to solve the physics problem of fluid material. Data analysis techniques used by using the normality test, homogeneity test and hypothesis testing with analysis of variance techniques (ANOVA). This analysis is to test whether there is an influence of the interaction of project-based learning methods with problem solving abilities on student learning outcomes.

3. Results and discussions

Cognitive learning outcomes were obtained from posttest. Meanwhile, the results of problem solving ability were obtained from essay tests in the experimental class and the control class after learning using the project based learning method on fluid material. Before being given, the questions were tested to another class (the class was neither a control class nor an experimental class). After being tested, the questions were validated by experts (lecturers and colleagues). Then, data were analyzed using the normality test, homogeneity test and hypothesis testing with analysis of variance techniques (ANOVA).

The normality test is used to test whether the data has a normal distribution or not. The normality test uses SPSS 18 using Lilliefors significance and Kolmogorov-Smirnov techniques at a significance level ($\alpha$) of 0.05. The homogeneity test is intended to find out whether the data obtained from a varied population is homogeneous or not. Homogeneity testing is carried out using the Lavene test on the SPSS 18. The hypothesis testing of this study uses analysis of variance. Analysis of variance technique is a research design used to examine the influence of treatment of different learning methods from two classes. They connected to the high and low problem solving abilities of student learning outcomes. The cognitive aspects of the histogram graph are shown in figure 1.

![Histogram](image)

**Figure 1.** Comparison of students’ cognitive learning outcomes. Interval: A = 61–70, B = 71–80, C = 81–90, D = 91–100.

**Table 2.** Descriptions of the cognitive learning outcomes statistics.

| Statistics        | Control class | Experiment class |
|-------------------|---------------|-----------------|
| Mean              | 76.43         | 85.14           |
| Median            | 75            | 85              |
| Modus             | 85            | 85              |
| Standard deviation| 5.50          | 4.29            |
| Variance          | 30.25         | 18.36           |
| Maximum           | 85            | 95              |
| Minimum           | 65            | 75              |
From the histogram in figure 1, the cognitive learning outcomes in the control class were achieved by students at most in the 71–80 interval. While in the experimental class the most project-based learning method was achieved by students at 81–90 value intervals. Descriptions of the cognitive learning outcomes statistics of the control class and experimental class can be seen in table 2.

Problem solving ability of control class students and experimental class with project based learning method can be presented by histogram and it is shown in figure 2. From figure 2, it can be seen that the problem-solving ability of the control class is mostly achieved by students in interval 71–80 and interval 81–90 are achieved by the experimental class. The statistical description of problem solving in the control class and experimental class can be seen in table 3.

![Figure 2. Comparison of students’ problem solving ability. Interval: A = 61–70, B = 71–80, C = 81–90, D = 91–100.](image)

| Statistics            | Control class | Experimental class |
|-----------------------|---------------|--------------------|
| Mean                  | 75.31         | 81.51              |
| Median                | 75.00         | 82.00              |
| Modus                 | 78.00         | 82.00              |
| Standard deviation    | 3.53          | 3.86               |
| Variance              | 12.45         | 14.90              |
| Maximum               | 82.00         | 92.00              |
| Minimum               | 69.00         | 75.00              |

From the statistical data that has been obtained for the next data is analyzed using normality test, homogeneity test and hypothesis test. The results of the normality test of the control class and the experimental class were obtained sig > 0.05, so it can be concluded that the data is normally distributed. The homogeneity test results of cognitive learning results obtained sig > 0.05, so it can be concluded that cognitive learning outcomes are homogeneous. The results of the homogeneity of problem solving ability obtained by the results of sig > 0.05, so it can be concluded that the data are homogeneous problem solving abilities.

After the normality test and homogeneity test were fulfilled then hypothesis testing was continued. Hypothesis testing was used to process data from research results in the form of numbers so that it can produce conclusions that provide answers to the problem statements submitted logically and systematically. Hypothesis testing is done by using two-way analysis of variance (ANAVA) at a
significant level of $\alpha = 0.05$. The statistical hypothesis proposed in this study was as follows. $H_0 =$ there was no influence of the interaction between learning method with problem solving ability on student learning outcomes. $H_1 =$ there was an influence of the interaction between learning method with problem solving ability on student learning outcomes. Anova results for the influence of learning methods and problem solving abilities on cognitive learning outcomes are shown in table 4.

Table 4. Influence of learning methods and problem solving ability on cognitive learning outcomes.

| Source                                      | Sig. | Conclusion  |
|---------------------------------------------|------|-------------|
| Learning method                             | 0.000| $H_1$ accepted |
| Problem solving ability                     | 0.000| $H_1$ accepted |
| Learning method and problem solving ability | 0.043| $H_1$ accepted |

Anova results for the influence of the learning method on cognitive learning outcomes show a significant level less than 0.05, then $H_0$ is rejected so it can be concluded that there is an influence of learning methods on cognitive learning outcomes. Anova results for the influence of problem solving abilities on cognitive learning outcomes showed a significance level less than 0.05, then $H_0$ was rejected so that it can be concluded that there is an influence on the ability of problem solving on cognitive learning outcomes. Anova results for the influence of the interaction of learning methods with problem solving abilities on cognitive learning outcomes showed a significant level of 0.043 which is smaller than 0.05, then $H_0$ is rejected so it can be concluded that there is an interaction influence between learning methods and problem solving abilities on cognitive learning outcomes.

The test results showed that the average cognitive learning outcomes and problem solving abilities in the class given the project based learning method were higher than the control class. This shows that there is an increase in student learning outcomes if the learning process uses methods that are appropriate to the material and attractive to students. This is in line with the study [15] which states that the increase in students’ problem solving ability is inseparable from the stages of the project-based learning model applied to the experiment class. Making projects in the learning process can help students think reflective. Another study conducted by [9] showed that learning with project based learning methods had a good influence on learning outcomes. Learning with the project based learning method has a process of teaching new knowledge concepts. Students are directed to the initial supporting knowledge, given the procedures performed and the facts of the experimental results which are then analyzed to draw conclusions in the form of projects. The results of this study are also in accordance with the results of study [16] that revealed learning with the project based learning method requires students to use the entire senses to find concepts along with guidance from the teacher that helps students to be involved in each stage of learning. Direct involvement of students in building concepts results in higher mastery of concepts.

4. Conclusion

Based on the results and discussion on the research that has been described, there was an influence between the interaction of project-based learning methods and problem-solving abilities on student learning outcomes. The students learning outcomes of the experimental class are higher than students who study conventionally. This is inseparable from the learning method used. In addition to making projects, students are also given problems that can lead them to develop concepts and learn to solve problems in groups. From the results of research and discussion, suggestions that can be given include: (1) for teachers as instructors need to make careful preparation in designing learning by giving problems that can make students active and creative, so that positive interactions occur during learning. However, teachers who want to carry out learning using the project based learning method need to pay attention
to the time allocation with the difficulty level of the project that students must do. (2) for further research, the results of this study can be used as reference to conduct further research using different material or by measuring other variables.

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