Implementation of Project-Based Learning Model to Physics Problem Solving Skills of Grade X High School Student

Riski Safitri[1]*, Jumadi[2], Lia Wahyuningsih Budiardi[1], Aifa[3], & Dea Nanda Putri[1]
[1]Department of Physics Education, Tanjungpura College of Teacher Training and Education, Indonesia
[2]Department of Physics Education, State University of Yogyakarta, Indonesia
[3]Physics Education Study Program, Universitas Muhammadiayah Makassar, Indosensia
*Corresponding author: safitrisky827@gmail.com

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Abstract *–This study aims to: (1) obtain information on the physics problem-solving skills of class X MIPA 1 SMA students before being taught using a project-based learning model, (2) obtaining information on the physics problem-solving skills of class X MIPA 1 High School students after being taught using a project-based learning model. This type of research is pre-experimental research with a One Group pretest-posttest design consisting of three stages, namely pretest, treatment for 6 meetings, and posttest. In this study there are two variables, namely the dependent variable of problem-solving skills and the independent variable of project-based learning model. The sample in this study was 33 students of class X MIPA 1 SMA, determined by simple random sampling. The results of the study showed that in the pretest, the students' physics learning outcomes obtained an average score of 30 and in the posttest, the average score obtained was 73. The research instrument used was a physics problem-solving skills test that met the valid criteria of 10 items with a normalized N-gain test score of 0.61 so that it can be concluded that the physics problem-solving skills of class X MIPA 1 SMA students increased to the Moderate category.*

Keywords*: Project based learning model; Problem solving skills*

INTRODUCTION

Education in Indonesia is a very important component in the role of forming an individual's personality. Education seeks to help students cope with life's tasks independently and responsibly (Saputra, 2020), and requires individuals to have a variety of skills that need to be mastered, so that education is expected to equip students with these skills to achieve success in the future (Jayadi et al., 2020). This view is in line with Article 13 paragraph (1) of the Republic of Indonesia Law Number 20 of 2003 concerning the National Education System which states that basic education is organized to develop attitudes and abilities and provide basic knowledge and skills. The explanation of Article 13 paragraph (1) emphasizes that basic education aims to improve students' abilities in the cognitive, affective, and psychomotor domains. Thus, these three domains indicate that basic education must be complete and comprehensive, because it does not only aim to make children "smart" academically, but also have good character and skills through balanced cognitive, affective, and psychomotor development.

Every individual who becomes an Indonesian citizen has the right to obtain quality education. Education is not merely a process of transferring knowledge from teachers to students, but also related to the development of the students' own learning abilities. However, it is not uncommon for students to experience boredom or stagnant conditions in the learning process (Sudarsana, 2016). Students are required to be able to solve problems in various complex problems because problem-solving skills are an important aspect to train so that students can solve problems related to physics

concepts (Siregar et al.,2022). Therefore, an innovative learning process is needed to help students get a good education.

Problem solving skills can be trained through the learning process. These skills can be used to complete tasks that can be related to high-level thinking skills (Mahardika et al., 2021). This problem-solving skill can be seen from how students investigate a problem and find a way to solve the problem given (Gillette, 2017). These skills are needed to activate reasoning based on observations and data such as testing hypotheses, solving complex problems, and being able to work well in a team during the learning process (Fitriyani et al., 2019). However, students' problem-solving skills are still low and require increased thinking in problem solving through learning, in order to gain a comprehensive understanding of the material. Natural Sciences (IPA), especially physics, is a science that studies natural phenomena and their changes. In essence, physics is a field of learning that studies natural phenomena through a systematic process to find theories, concepts, facts, and principles. Physics is not just an effort to gain knowledge, but is a process of scientific discovery (Darta, 2020). Physics learning with all the events in it will be more meaningful if it is studied contextually by involving more students to be able to explore in order to form competencies by exploring various potentials and truths scientifically to improve students' skills (Makiyah et al., 2021). Students' skills in the problem-solving learning process are still very weak or lacking, resulting in students having difficulty solving various problems in physics learning (Febriani et al., 2021). Lack of conceptual understanding in problem-solving skills causes the learning process to become weak, because students have difficulty responding to the learning provided by the teacher.

Through physics learning, students are provided with a platform to develop their knowledge, skills, and confidence in understanding natural phenomena scientifically. However, in its implementation in schools, physics subjects are often considered difficult for some students (Chen et al., 2022). Meanwhile, physics learning itself aims to develop students' thinking and problem-solving skills (Ridho et al., 2020; Yuberti et al., 2019) Physics materials often experience incompleteness when evaluated at the end of the learning program. This is because the physics learning outcomes obtained by students are still not optimal (Najwa et al., 2022). In addition, teachers also experience obstacles in instilling concepts appropriately in students so that they can solve physics problems appropriately (Sayyadi et al., 2016). With this kind of learning in schools, students will have difficulty understanding concepts and will not be able to solve a problem. Based on the results of the research that have been described, it can be seen that students' problem-solving skills are in the low category in physics learning.

In addition, in physics learning at secondary education level, students are rarely invited to learn to apply the physics concepts they have learned in creating real projects (Ediana et al., 2023). In fact, the physics concepts he studied were very useful and played a big role in developing various technological products (Yuliani et al., 2024). Finally, learning is more teacher-centered or commonly called a conventional learning model so that the learning that is carried out tends to be boring and will directly result in low student learning outcomes (Jafar, 2021). So it is necessary to find the right solution to overcome this problem.

Based on the results of observations that have been carried out by interviewing physics teachers of class X MIPA 1 SMA N

6 Kepulauan Selayar, it was found that students' physics problem-solving skills were not as expected. Students experience difficulties when solving problems that have slight differences with the example problems and students are weak in understanding the concept and in making solutions so that it can be concluded that most students' abilities in mastering physics are still low. This is proven by the value of students totaling 34 people in the odd semester who completed 44.12% or 15 people, while those who have not completed 55.88% or 19 people from the Minimum Completion Criteria (KKM) standard that has been set, namely 60, so that to achieve KKM students need to carry out repetition/remedial. Therefore, it is necessary to create learning innovations that apply learning models that overcome the problems that exist in students in learning physics.

Physics learning requires the implementation of models based on scientific approaches so that students can understand concepts in a coherent and reasonable manner. In essence, physics is a science that is scientific in nature (Zulkipli et al., 2020). Meanwhile, the project-based learning model is a learning model that involves project activities in the learning process (Baran et al., 2018). Project-based learning is implemented in a collaborative, innovative and unique manner, with a focus on solving problems that are relevant to students' lives (Hussein, 2021). The main goal is to produce a real product as the end result of the learning process. Project-based learning has great potential to make the learning experience more interesting and meaningful for students in building work skills (Schneider et al., 2022). This is in line with research conducted by Siregar (2017) in his research, it was found that the project-based learning model can have a direct impact on students in the form of improving physics learning outcomes, which means that students' problem-solving abilities increase (Retno et al., 2019). Therefore, the project-based learning model is considered suitable to be applied in the learning process for students' physics problem-solving skills and has an impact on learning outcomes and is able to encourage students to produce contextual work, both individually and in groups, so it is highly recommended to use a learning approach that produces work, namely project-based learning.

The novelty of this study lies in the effort to obtain empirical information regarding the physics problem-solving skills of class X MIPA 1 students before and after being taught using a project-based learning model, especially in the context of physics learning on the material of Straight Motion Kinematics in one of the high schools in the Selayar Islands. Different from previous studies that focused more on improving learning outcomes in general, this study specifically examines changes in problem-solving skills through a comparison of initial conditions (pretest) and conditions after treatment (posttest), thus providing a real picture of the effectiveness of the project-based learning model in overcoming the low ability to solve physics problems in classroom learning. These findings are expected to be a new contribution in the development of project-based physics learning strategies as an alternative solution to overcome the problems of conventional learning that still dominates in schools.

Based on the description above, the researcher is interested in conducting research by raising the problem into a scientific work entitled the implementation of project-based learning model to physics problem solving skills of class X high school students.

RESEARCH METHODS

The type of research used is a quantitative research type using the pre-experimental design method with the One Group Pretest-Posttest Design research design which measures changes in physics problem-solving abilities before and after the project-based learning model is applied to one group of class X students. Where in this design before the treatment is given, the sample is given an initial test (pretest) and at the end of the learning the sample is given a final test (posttest). The research design can be seen in Figure 1:

Pretest	*Treatment*	*Posttest*
O_1	X	O_2

Figure 1. Research Design

Description:
X = Treatment using project-based learning model
O_1 = Initial test score (pretest) before being given treatment
O_2 = Final test score (posttest) after being given treatment

The instrument used in this study was a problem-solving skills test. The test is used to measure the level of students' problem-solving skills. The instrument used was an essay test. The test used to determine problem-solving skills is a question that contains aspects of problem-solving skills indicators, namely the ability to understand problems, plan problem solving, solve problems, and conclude.

The descriptive data analysis technique used is the presentation of data in the form of average scores and standard deviations. This analysis is intended to present or reveal students' problem-solving skills by grouping them into the minimum learning completion standards used at SMA, to determine the average score of students using the formula:

$$\bar{X} = \frac{\sum f_i x_i}{\sum f} \quad (1)$$

Description:
$\bar{X}$ = Average score
$\sum fixi$ = Total score of students
$\sum f$ = Number of students

Determine the standard deviation using the formula.

$$S = \sqrt{\frac{\sum f_i x_i^2 - \frac{\left(\sum f_i x_i\right)^2}{n}}{n-1}} \quad (2)$$

Description:
S = Standard deviation
x_i = Student scores
f_i = Frequency of students
n = Number of research subjects

The criteria for categorizing students' problem-solving skills are adopted from the criteria for categorizing students' learning outcomes according to Sugiyono (2015), namely.

Table 1. Categories of Student Learning Outcome Values

Interval	Category
85 -100	Very High
70 – 84	High
60 – 69	Enough
51 – 59	Low
0 - 50	Very Low

After all the data has been collected, to determine the increase in students' problem-solving skills, the N-Gain test was used.

1. Calculate the Gain of each student using the equation
   G = Posttest Score – Pretest Score
2. Determine the normalized Gain (N-Gain) with:
   $g = \frac{Posttest\ Score - Pretest\ Score}{maximum\ possible\ score - pretest\ score}$

With the N-gain index interpretation criteria, namely.

Table 2. Gain Index Criteria

Gain Index	Criteria
$g > 0{,}70$	High
$0{,}70 \geq g \geq 0{,}30$	Medium
$0{,}30 > g$	Low

RESULTS AND DISCUSSION

Results

Descriptive Statistical Analysis Results

The results of the research from the field study to obtain data through the provision of tests before and after a treatment was carried out in the research class. So the variables studied are physics problem solving skills using a project-based learning model, with the material of Straight Motion Kinematics in class X MIPA 1 students at one of the high schools in Selayar.

The results of the physics problem-solving skills test of class X MIPA 1 SMA students before and after being taught by implementing a project-based learning model, namely.

Table 3. Problem Solving Skills Score Results of Class X MIPA 1 Students during the Pretest and Posttest

Statistics	Pretest Statistics Score	Posttest Statistics Score
Highest Score	66	78
Lowest Score	10	68
Ideal Score	100	100
Standard Deviation	16,267	2,404
Variance	264,615	5,779
Average Score	**30**	**73**

The statistical results in table 3 show that students' physics problem-solving skills increased significantly after the learning process implemented the project-based learning model, as seen in the increase in the average score, the increase in the minimum and maximum scores, and the decrease in the standard deviation and variance, which indicates that the increase is not only significant, but also even. This shows that the learning strategy implemented using the project-based learning model is very effective in students' physics problem-solving skills.

Pretest Data Research Results

The data results in table 3 show that the highest pretest score before using the project-based learning model from 33 students of class X MIPA 1 SMA on Straight Motion material is 66 and the lowest score is 10 from the ideal score of 100, and the average score of students is 30 with a standard deviation of 16.267. If the student's score is analyzed using the percentage of frequency, it can be seen in the following table 4.

Table 4. Percentage Frequency of Scores of Class X MIPA 1 SMA Students during the Pretest

Score Range	Category	Frequency
85 – 100	Very High	-
70 – 84	High	-
60 – 69	Enough	4
51 – 59	Low	1
85 – 100	Very High	-
Amount		**33**

Posttest Data Research Results

From table 3, it also shows that the highest posttest score after using the project-based learning model from 33 students of class X MIPA 1 SMA on Straight Motion material is 78 and the lowest score is 68 from an ideal score of 100, and the average score of students is 73 with a standard deviation of 2.404. The results of the quantitative descriptive analysis for the problem-solving skills scores of students using the project-based learning model can be seen in the following table.

Table 5. Percentage Frequency of Scores of Class X MIPA 1 SMA Students During the Posttest

Score Range	Category	Frequency
85 – 100	Very High	-
70 – 84	High	31
60 – 69	Enough	2
51 – 59	Low	-
0 – 50	Very Low	-
Amount		**33**

The following is a graph of the percentage frequency distribution of the physics problem-solving skills scores of class X MIPA 1 SMA students on the Straight Motion material before and after implementing the project-based learning model.

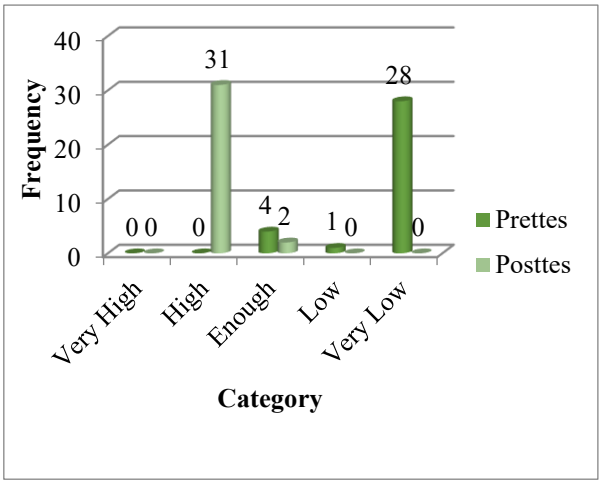

Figure 2. Percentage Frequency Distribution of Problem-Solving Skills Scores in the Pretest and Posttest of 33 Students in Class X MIPA 1

Based on Figure 2, the frequency distribution graph of the physics problem-solving skill category, there is a very significant increase between the pretest and posttest results. Before learning (pretest), most students were in the very low category, which was 28 people. One student was in the low category, and only 4 people were in the sufficient category. Not a single student was included in the high or very high category. This condition reflects that the initial ability of students in solving physics problems is still very low and uneven. After learning (posttest), there was a drastic shift towards a higher category. As many as 31 students from all were in the high category, while 2 students were in the low or very low categories. Meanwhile, the very high category has not been achieved by students, which is caused by scores that have not approached the maximum ideal value (100). This change in distribution shows that learning with the project-based learning model provided is very effective in improving students' skills in solving physics problems. Not only was there an increase in the average score, but there was also an even distribution of achievement, as indicated by the decreasing frequency in the low category and the increasing concentration of students in the high category. Thus, it can be concluded that the learning strategy with the project-based learning model used was able to improve physics problem-solving skills significantly and evenly.

N-Gain Analysis Results

The increase (N-Gain) in the results of physics problem-solving skills of class X MIPA 1 SMA students was obtained by comparing the results of the pretest and posttest. The results of the N-Gain achievement of general students of class X MIPA 1 SMA students who were taught using the project-based learning model on problem-solving skills. To find out the increase in students' physics problem-solving skills in the low, medium, and high categories, it was analyzed using the N-Gain analysis. The results of the N-Gain test calculation from the pretest and posttest physics score data of class X MIPA 1 SMA students after being taught using the project-based learning model on physics problem-solving skills can be seen in table 6 below.

Table 6. Distribution Percentage of N-Gain Achievement of Class X MIPA 1 Students

Criteria	N-Gain Index	Frequency	Persentase (%)	Average N-Gain
High	$g \geq 0{,}70$	1	3,03	**0,61**
Medium	$0{,}30 \leq g < 0{,}70$	30	90,91	
Low	$g < 0{,}30$	2	6,06	
Amount		**33**	**100**	

Based on table 6, it can be concluded that more than 90% of students experienced

an increase in learning outcomes in the medium to high category, which shows that learning carried out using a project-based learning model is effective in improving physics problem-solving skills. The average N-gain of 0.61 indicates a medium category but approaches high overall.

Discussion

This study is a pre-experimental study that compares the scores of problem-solving skills before the project-based learning model is applied (pretest) with the scores of problem-solving skills after the project-based learning model is applied (posttest) in one sample class. The problem-solving skills test that will be used has been validated first (expert and item). After being validated, the test is considered valid and then given to students who are the subjects in this study, namely students of grade X MIPA 1 SMA. Based on the results of the descriptive analysis of the pretest, the highest score was 66, the lowest score was 10, and the average score was 30 with a standard deviation of 16.267. While in the posttest, the highest score was 78, the lowest score was 68, and the average score was 73 with a standard deviation of 2.404. These data show that the problem-solving skills of students obtained in the posttest are higher than in the pretest. The high posttest results are due to the influence of learning using the project-based learning model on physics problem-solving skills in the learning process. From the results of data analysis using descriptive statistics in general, it can be stated that in the posttest the average score of physics problem-solving skills of class X MIPA 1 SMA students is higher than the average score in the pretest. Furthermore, the N-Gain test produced 0.61 which is in the moderate category. In general, it can be said that the project-based learning model can improve physics problem-solving skills in the Straight Motion material of class X MIPA 1 SMA. This is in line with research conducted by Siregar (2017) in his research, it was found that the project-based learning model can have a direct impact on students in the form of improving physics learning outcomes, which means that students' problem-solving abilities increase. Project-based learning can improve students' problem-solving abilities and make students more active in solving complex problems (Kristanti et al., 2012). And research conducted by (Setyawan et al., 2019) stated that the percentage of student learning outcomes completion reached 95% using the project-based learning model which was declared successful and tested. Therefore, the project-based learning model is considered suitable to be applied in the learning process to improve students' physics problem-solving skills. Thus, the implementation of the project-based learning model in this study tends to be able to improve the physics problem-solving skills of class X MIPA 1 SMA students, which is indicated by change seen from the comparison between the results of the pretest and posttest.

CONCLUSION

Based on the problem formulation, research results and discussion, it can be concluded that physics problem-solving skills before the implementation of the project-based learning model in class X MIPA 1 SMA students are seen from the average score obtained, namely 30 which is in the very low category. The physics problem-solving skills after the umplementation of the project-based learning model in class X MIPA 1 SMA students are seen from the average score obtained, namely 73 which is in the high category. The physics problem-solving skills of class X MIPA 1 SMA students have

increased as seen from the average N-Gain criteria, namely 0.61 which is included in the medium category. So, the researcher hopes that further researchers can continue the research and implement project-based learning models on other physics materials to complement this research.

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