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Project Based Learning With Stem On Alternative Energy Materials To Improve Problem Solving Skills In High Schools

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Abstract

This study aims to determine the effectiveness of STEM-PjBL learning in improving students' problem-solving abilities in alternative energy materials. This research was conducted in one of the high schools in the city of Bandung. Samples were obtained by rational sampling of 35 students in class X MIPA I (experimental class) and 35 students in class X MIPA II (control class). The method used is a quasi-experimental design with a non-equivalent control group design. Data collection technique is a description test in the form of pre-test and post-test. Based on data analysis it is known that the use of STEM-PjBL can improve students' problem solving skills (N-Gain = 0.65) in the experimental class compared to the control class (N)-Gain = 0.44). The t-test results with SPSS 22 with Sig. (2-value) less than 0.05 indicates that there is a significant difference in the increase in the problem solving ability of students in the experimental class and the control class. Based on these results, learning has a positive impact on students' problem solving abilities. STEM-PjBL learning can be used as an alternative teaching strategy at various school levels.
Keywords: STEM-PjBL, Problem Solving Skills, Alternative Energy Review

Project Based Learning dengan Stem Pada Materi Energi Alternatif untuk Meningkatkan Keterampilan Pemecahan Masalah Pada Sekolah Menengah Atas

Abstrak

Penelitian ini bertujuan untuk mengetahui keefektifan pembelajaran STEM-PjBL dalam meningkatkan kemampuan pemecahan masalah siswa pada materi energi alternatif. Penelitian ini dilakukan di salah satu SMA di kota Bandung. Sampel diperoleh secara purposive sampling sebanyak 35 siswa di kelas X MIPA I (kelas eksperimen) dan 35 siswa di kelas X MIPA II (kelas kontrol). Metode yang digunakan adalah quasi eksperimen dengan desain *non-equivalent control group design*. Teknik pengumpulan data adalah tes uraian berupa pre-test dan post-test. Berdasarkan analisis data diketahui bahwa penggunaan STEM-PjBL dapat meningkatkan kemampuan pemecahan masalah siswa (N-Gain = 0,65) di kelas eksperimen

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dibandingkan dengan kelas kontrol (N)-Gain = 0,44). Adapun hasil Uji-t dengan SPSS 22 dengan hasil Sig, (2-value) kurang dari 0,05 menunjukkan bahwa terdapat perbedaan yang signifikan peningkatan kemampuan pemecahan masalah siswa kelas eksperimen dan kelas kontrol. Berdasarkan hasil tersebut, pembelajaran memberikan dampak positif terhadap kemampuan pemecahan masalah siswa. Pembelajaran STEM-PjBL dapat digunakan sebagai salah satu alternatif strategi pengajaran di berbagai jenjang sekolah.

Kata kunci: STEM-PjBL, Pemecahan Masalah, Energi Alternatif

INTRODUCTION

Science and technology play an important role in the effort to answer future challenges. The pace of innovation in science and technology is increasing, the state must prepare human resources who have expertise in the dimensions of science and technology to be able to compete in the 2030 global industry. The quality of human resources in mastering the dimensions of science and technology makes the role of education the main key to increasing it. . In order to prepare human resources who are ready to face challenges in the 21st century (globalization era).

The 21st Century Competency Framework is the basis of the independent Curriculum in Indonesia that was developed for students. To support programs in Indonesia, learning that supports creativity is needed, emphasizing personal experience through problem solving. Problem solving skills are part of the skills needed in the world of work (Rios et al., 2020). Therefore, problem solving skills need to be developed at various levels of education (Rott et al., 2020; Scherer & Beckmann, 2014). Problem Solving Skills focuses on analysis in the process of selecting concepts that students need to solve problems (Rivai et al., 2017). Problem solving is considered one of the most important skills a person has (Rott, 2020; Safaruddin et al., 2020; Saadati et al., 2019; Walkington et al., 2019).

However, in reality, several studies have shown that students' problem-solving abilities in Indonesia are not in line with the government's expectations. Indonesian students' problem-solving skills are still relatively low compared to students from other countries (Purwaningsih et al., 2020; Chania et al., 2020; Pisa, 2019; Hasibuan et al., 2019). This condition is reinforced by Kartini et al. (2021) argued that the low quality of

Indonesian education also affected the percentage of problem-solving abilities of Central Java students with a percentage of 52.93% and showed low student problem-solving abilities (Jua et al., 2018). Based on this, the researcher conducted an interview with a physics teacher at a high school in Bandung about students' problem-solving abilities. Regarding the results of the interviews, specifically learning physics in schools is already oriented towards cooperative learning, and project-based learning is rarely done. Learning is done does not involve students solving problems and designing solutions to these problems. Even though students are doing practical work, students only follow the guidelines or work steps given by the teacher. Therefore, an authentic problem solving process is not carried out. Consequently, students are not trained to develop scientific solutions to a phenomenon or problem. Therefore, we need a learning process that can improve the ability to solve physics problems. Because of the importance of these problem-solving skills for students, learning provides students with real-world experiences in interacting with phenomena, while at the same time requiring students to improve their problem-solving skills by using integrated STEM learning with Project Based Learning.

STEM-PjBL is a rare innovation in learning that provides opportunities for students to jointly plan the learning process and create certain products that can be used as learning resources (Jauhariyyah et al., 2017). STEM project-based learning is a project-based model that integrates science, technology, engineering, and mathematics (STEM) into curriculum design (Lou et al., 2017). The interdisciplinary design and teaching process make STEM project-based learning unique. The design process for STEM project-based learning begins with the preparation of well-defined outcomes by setting objectives and planning a project's summative assessment. Furthermore, students will be given abstract assignments to express complex problem-solving ideas with different solutions (Capraro, Capraro, & Morgan, 2016).

STEM-PjBL learning helps students solve real world problems by developing and using their problem solving skills (Tyas et al., 2021; Hanif et al., 2019). The potential for an integrated STEM-PJBL approach is important in helping students develop problem-solving skills and linking classroom learning to the real world (MM Capraro & M. Jones, 2016). Many studies have proven that STEM project-based learning has an impact on many different aspects. STEM-PjBL includes a variety of hands-on activities, communication, and peer collaboration, helping students develop positive confidence in their ability to solve physics problems (Baran et al., 2021; Gestira et al., 2021; Apriyani et al. al. 2019). STEM-PjBL can be integrated into physics teaching materials such as modules and student workbooks (Asih et al., 2020). STEM-PjBL also affects students' critical thinking skills (Ridlo et al., 2020). And learning using STEM-PjBL can affect students' communication skills (Baran et al., 2021). Therefore, learning STEM with PjBL (STEM-PjBL) seems to have the potential to improve problem solving abilities. Therefore, researchers will try to apply STEM-PjBL learning as one of the innovations in physics learning in class X on alternative energy materials to see an increase in problem-solving abilities that are applied to this learning method.

RESEARCH METHOD

This study used a quasi-experimental method (Quasi Experiment) with a non-equivalent control group design (Creswell, 2018). The non-equivalent control group design can be seen in Table 1.1

Table 1.1 Non-equivalent control group design chart

Group	Pretest	Treament	Posttest
Experiment	O_1 O_2	X_1	O_1 O_2
Control	O_1 O_2	X_2	O_1 O_2

In this design there are two study groups, namely the experimental group and the control group. These two groups were given a pre-test to determine students' initial problem-solving abilities. After getting the pre-test, the experimental group will get a form of learning using the STEM-PjBL learning approach. while the control group will be trained using the discovery learning learning model. Then, the experimental group and the control group will take the final exam (post test) to measure the effect of STEM-PjBL learning on physics problem-solving skills. The population of this study consisted of 2 class X MIPA at one of the high schools in the city of Bandung. The research sample was conducted in class X MIPA I with a total of 35 students, and MIPA II with a total of 35 students. Sampling was carried out using the purposive sampling method.

These considerations include the schedule of subjects that will receive the concepts to be studied and based on the teacher's recommendations in fields of study that are relevant to students' abilities.

The test instrument used is a problem solving skills test developed by Heller and Heller (2010) which includes focusing on the problem, describing the physics problem, planning a solution, implementing the solution and evaluating answers. The data obtained were then analyzed using descriptive and inferential statistics. After obtaining the pretest and posttest scores, the processing of tests to improve students' problem solving and scientific communication skills was analyzed using the N-gain (g) technique (Meltzer, 2002):

$$< g >= \frac{\text{score postest} - \text{score pretest}}{\text{maximum score} - \text{skor pretest}}$$

The N-gain values obtained can be interpreted to determine categories with the criteria in Table 1.2

Limitation	Category
$<g> > 0,7$	High
$0,3 \leq <g> \geq 07$	Medium
$<g> <0,3$	Low

To see the average significant difference in the increase in problem solving skills in the experimental class, a prerequisite test was carried out, namely the normality and homogeneity tests of each pretest and posttest results were carried out before testing the hypothesis. The hypothesis test was selected based on the results of the prerequisite test using the SPSS 22 application. The hypotheses tested in this study are as follows:

H_o : There was no significant difference between the increase in physics problem solving skills in the experimental group and the control group.

H_a : There is a significant difference between the increase in physics problem solving skills in the experimental group and the control group

RESULTS AND DISCUSSION

The results of the pretest and posttest were measured using a problem solving skills test in the form of a description of 3 questions with a 0-4 scale assessment rubric.

experiment and control class on alternative energy materials. The recapitulation of increasing problem solving skills can be seen in Table 1.3.

Table 1.3 Results of the Average Physics Problem Solving Skills

Class	***Pretest***		***Posttest***	
	Exsperimen	Control	Exsperimen	Control
Mean	35,33	38,10	76,86	64,38
Scor Max	76,67	78,33	93,33	93,33
Scor Min	10,00	8,33	56,67	40,00
SD	18,4	20,5	10,2	14,89

Based on Table 1.3, it can be seen that the average pretest score for the experimental class using the STEM-PjBL model is 35.33 and 37.92 and the control class uses the discovery learning model of 38.10. The average pretest results were slightly higher in the control class compared to the experimental class. This shows that students' initial problem-solving skills can be said to be equivalent. After being given learning treatment in the experimental and control classes, the experimental class obtained an average posttest score of problem solving skills of 76.86 and the control class was 64.38 where the experimental class had an average score that was greater than the average class score control. Improved problem solving skills can also be seen from the N-Gain value. The N-Gain value recapitulation can be seen in Figure 1.1 as follows:

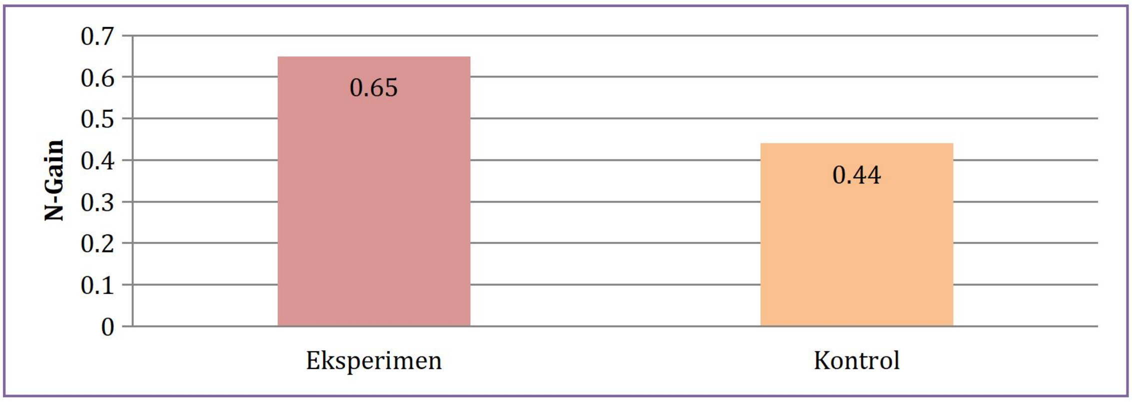

Figure 1.1 The average increase in N-gain Problem Solving Skills

Improved problem solving skills in experimental class I and II based on the N-gain value of 0.65 and for the control class of 0.44 with. This shows that the increase in the N-Gain value in the experimental class is greater than the increase in the N-Gain value in the control class. The results of this increase in N-Gain were confirmed by the category of Hake (1996), so the increase in problem solving skills in the experimental class and the control class was in the medium category. Even though they were both in the medium category, the acquisition of problem solving skills tests in the experimental class experienced a greater increase than the control class. In line with research conducted by Yuliati et al., (2019) in Tulungagung, East Java, found that after the impact of STEM Project-Based Learning, the experimental class had an N-gain score of 0.43 with a moderate improvement category better than the control class which only 0.19 with a low category.

In addition to using n-gain to determine the increase in problem solving skills, it is necessary to look at the significance of the difference in the increase in problem solving skills before and after the STEM-PjBL model is applied to the experimental and control groups. The steps for testing the hypothesis are carrying out a normality test on the pretest and posttest scores. Then if the data is normally distributed, a parametric test is carried out, namely the independent sample t test. But if the data is not normally distributed, a parametric test is performed, namely the Mann Whitney test. To test the normality of problem solving using the Kolmogorov-Smirnov test through the SPSS 22 application with testing criteria at significance > 0.05, the data is normally distributed. The results of the normality test analysis between the STEM-PjBL class and the control class are presented in Table 1.4

Table 1.4 Recapitulation of the Normality Test of Problem Solving Skills

Tests of Normality			
Kelas	Kolmogorov-Smirnov[a]		
	Statistic	df	Sig.
PreTest Ek	0,11	35	0,200*
PostTest Ek	0,11	35	0,200*
Pretest Kontrol	0,08	35	0,200*
PostTest Kontrol	0,07	35	0,200*

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Based on Table 1.4, the pretest and posttest significance value (Sig.) data in the experimental class and control class is greater than 0.05. That is, the six data are normally distributed. In addition to carrying out the normality test, then to determine the inferential statistical test used, a homogeneity test is carried out. This homogeneity test uses the Levene test to carry out the SPSS 22 program with a significance level with testing criteria at significance > 0.05, so the data is distributed homogeneously. The results of the homogeneity test analysis between the STEM-PjBL class and the control class are presented in Table 1.5.

Table 1.5 Homogeneity Test of Problem Solving Skills

Test of Homogeneity of Variance				
	Levene Statistic	df1	df2	Sig.
Based on Mean	2,902	2	103	0,059
Based on Median	2,452	2	103	0,091
Based on Median and with adjusted df	2,452	2	94,48	0,092
Based on trimmed mean	2,808	2	103	0,065

Based on Table 1.5, the significance value obtained is 0.059 greater than 0.05 (0.059 > 0.05) which indicates that the data is distributed homogeneously. Because the results obtained are data that are normally distributed and homogeneous, the hypothesis test uses the Independent Sample T Test. The results of the t-test carried out using SPSS 22 are presented in Table 1.6

Table 1.6 Independent Sample T Test Results

Independent Samples Test				
t-test for Equality of Means				
t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
4,40	104	0,000	11,95309	2,71661
4,080	56,13	0,000	11,95309	2,92933

Based on the results of testing the hypothesis using an independent sample t-test as shown in Table 1.6, it can be seen that Ho is rejected with Sig, (2-tailed) less than 0.05. Thus, it can be said that Ha is accepted, that is, there is a significant difference between the increase in problem solving skills of the experimental group and the control group. Therefore, it can be concluded that the STEM-PjBL learning provided can improve problem solving abilities compared to using discovery learning.

DISCUSSION

Problem solving skills in this study were measured through a description test of 3 questions adapted from Heller and Heller (2010). Testing the problem solving skills test was carried out twice, namely before (pretest) and after being given treatment (posttest) in the experimental class and the control class. Students' initial problem solving skills are relatively low. The low problem-solving skills of students can be seen from the pretest average obtained, namely 35.33 for the experimental class and 38.10 for the control class. After being given the learning treatment in the STEM-PjBL class and the control class, the experimental class I and II obtained an average posttest score of problem solving skills of 76.86 and the control class of 64.38 in which the experimental class had an average score that was greater than the the average score of the control class.

Improved problem solving skills can also be seen from the N-Gain value. In the experimental class, the N-gain value is 0.65 in the moderate category and for the control class it is 0.44 in the moderate category. Because it is in the medium category, it is necessary to test the significance difference. Based on the results of the normality and homogeneous tests, the tests were carried out using the Independent Sample T Test. The result is that Ho is rejected with Sig, (2-tailed) is smaller than 0.05. Thus, it can be said that Ha is accepted, that is, there is a significant difference between the increase in problem solving skills of the experimental group and the control group. Therefore, it can be concluded that the STEM-PjBL learning provided can improve problem solving abilities compared to using discovery learning.

This might happen because in this study learning in the experimental class provides a learning experience that is challenging and more real than Discovery Learning. For example, in the experimental class, students were challenged to make a simple hydroelectric generator capable of turning on a 5 watt LED with different water levels. Teachers can provide Learning Engagement by providing challenges to students (Duncan, 2020; Morrison et al., 2020). Whereas in the control class that uses Discovery Learning, students learn to discover concepts through virtual lab experiments. The virtual laboratory program used may not be able to determine the factors that can affect the amount of power generated by a power plant. The same thing was found by

Purwaningsih et al. (2017) who conducted research on the effect of STEM-PjBL and Discovery Learning on improving students' problem solving skills on impulse and momentum topics. Based on data analysis using the Mann-Whitney test, the significance value obtained is 0.03 where the value is smaller than the significance value (α = 0.05), which indicates that Ho is rejected and Ha is accepted. These results indicate that statistically, there is a significant difference between the problem solving skills of students who learn using STEM-PjBL (Mdn=78.74) and students who learn using Discovery Learning. As previously explained, this research was conducted by integrating the Project Based Learning model with the STEM approach. In STEM-PjBL learning, students are more trained and challenged to solve problems in everyday life compared to comparison classes, learning in the experimental class is better able to accommodate students' ideas and makes students more interested in learning.

CONCLUSION

Based on the results and discussion conducted, STEM-PjBL learning can improve students' problem solving skills in alternative energy material. So that it can be used as input for physics teachers to apply the STEM-PJBL approach in the physics learning process at various levels of education.

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