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Implementation of PJBL-STEM on Disaster Mitigation Sub-Matter to Improve Students' Problem-Solving Ability

Lintang Mahardhika[1], Risa Dwita Hardianti[1]*

[1]Science Education Program, Faculty of Mathematics and Natural Science
Universitas Negeri Semarang, 50229

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*Corresponding author:
Risa Dwita Hardianti
Universitas Negeri Semarang
E-mail: risadwita@mail.unnes.ac.id

Abstract

One of the objectives of science learning is to guide students in solving and finding appropriate solutions to problems related to natural phenomena that occur in daily life. Therefore, a learning process that facilitates the development of problem-solving skills in science learning is highly necessary. The purpose of this study was to determine the difference and level of problem-solving ability of students between before and after applying learning with PjBL-STEM on disaster mitigation sub-materials. This research is an experimental research with a group pretest-posttest research design. The data collection methods used are test and documentation methods. The instruments used include a pretest and a posttest. The data were analyzed descriptively and quantitatively. The results obtained are that the application of PjBL-STEM on disaster mitigation sub-materials can improve students' problem-solving skills. This is indicated by the results of the t-test, which shows the difference in results between before and after the application of PjBL-STEM, as well as the results of the N-Gain test of 0.57 with a moderate category. The level of students' problem-solving abilities after implementing PjBL-STEM as a whole is within good criteria. The highest level of students' problem-solving abilities is in the indicator of understanding the problem, while the lowest level is in the indicator of devising a plan.

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INTRODUCTION

Based on Permendikbud Number 16 of 2022, which explains that in the independent curriculum, learning strategies must be designed to provide opportunities for students to apply material to real problems or contexts. This is because 21st-century learning requires students to understand how the knowledge and abilities they learn can be applied in real-life situations. The four main principles of 21st-century learning are: 1) instruction should be student-centered; 2) education should be collaborative; 3) learning should have context (Griffin & Care, 2015; Rahayu et al., 2022).

PjBL-STEM is one of the learning strategies that is able to direct students to the principles of 21st-century learning. This project-based learning model has characteristics, namely: 1) projects are focused on issues related to the subject matter, 2) projects engage students in constructivist inquiry, 3) student-centered learning, and 4) projects are realistic, not school-like (Steenhuis & Rowland, 2018; Thomas, 2000). The involvement of constructivism in PjBL puts learners at the center of learning, thus allowing them to actively build knowledge through exploration (Diana & Sukma, 2021).

The results of research by Pratiwi et al. (2021) show that learning with PjBL-STEM is able to improve 21st-century skills by providing problem-solving experience through experimental activities and increasing students' interest in learning. In addition, research by Priatna et al. (2022) shows that the PjBL-STEM model is effective in improving problem-solving skills resulting from learning activities involving problem identification, discussing to determine solutions, and perfecting the findings to be able to direct students to problem-solving ability indicators. It is also supported by Parno et al. (2019), whose research shows that PjBL-STEM is able to influence the improvement of students' problem-solving skills.

A number of previous studies have found that many students in Indonesia still experience difficulties in solving problems, even though the problems are in accordance with the science material that the teacher has provided. The results of the study by Sari et al. (2021) found that students' problem-solving skills were dominated by a low level of problem-solving because they were only able to meet the indicators of submitting conjectures.

A similar problem was found at SMP Negeri 27 Semarang based on the analysis of evaluation questions used by the teacher. The results showed that 40.6% of 32 students were not able to answer questions containing indicators of problem-solving skills. The evaluation only included a limited number of questions that represented problem-solving indicators, and these were restricted to understanding the problem and devising a plan.. In the indicator of understanding the problem, students were expected to identify the known elements, the required elements, and the values needed to solve the problem. However, some students only wrote the final answer without providing clear and relevant reasoning to support it. In the indicator of devising a plan, students were expected to determine appropriate steps to solve the problem using various strategies. In fact, during the learning process, most students still struggled to identify the proper steps to solve problems related to science. The selection of inappropriate learning designs and not focusing on problem-solving causes students' problem-solving skills to need to be improved, because inappropriate learning designs are not able to facilitate indicators of problem-solving skills to appear in every learning process (Mariana et al., 2022).

Based on the background of the problems that have been presented, in this study, it is proven that PjBL-STEM is able to improve students' problem-solving skills in science learning, especially in disaster mitigation sub-materials, by knowing the difference in problem-solving skills between before and after the implementation of PjBL-STEM, as well as knowing the level of problem-solving skills after learning with PjBL-STEM.

METHOD

The research design used in this study is experimental, which uses a one-group pretest-posttest design. The experimental class was given a pretest to determine the initial ability of students, which was symbolized by O_1. After that, the experimental class was given treatment in the form of learning with PjBL-STEM and given a posttest whose results were symbolized by O_2 (Sugiyono, 2015). The design of the research carried out is presented in Table 1.

Table 1. Research design

O_1	X	O_2

(Sugiyono, 2015)

Information :
O_1 = experimental class pretest
O_2 = experimental class posttest
X = PJBL-STEM treatment

The research was conducted at SMP Negeri 27 Semarang. The population used was all VIII-grade students of SMP Negeri 27 Semarang. The sampling technique used in this study was cluster random sampling. Homogeneity test was conducted using STS score data of class VIII, even semester of the 2023/2024 school year. The sampling process obtained one class, namely class VIII C, as an experimental class of 31 students. The data collection method in this study used the test method. The results were then analyzed with the help of Microsoft Excel and SPSS 25.0.

RESULT AND DISCUSSION

The results of the pretest and posttest were tested for normality to determine whether the data obtained were normally distributed or not. The results of this test are used to determine the type of data analysis that will be used in the next stage. The normality test on the pretest and posttest data was tested using the Shapiro-Wilk formula, assisted by SPSS Statistics 25, with the results presented in Table 2, which shows that the normality test results for the pretest and posttest value data have a normal distribution because the Sig value. > 0.05.

Table 2. Normality test results

	Statistic	df	Sig.
Pretest	.967	31	.446
Posttest	.972	31	.565

The data is known to be distributed normally, so a paired sample t-test is carried out to find out if there is a difference in the average problem-solving ability between before and after being given PjBL-STEM treatment. The results of the paired sample t-test can be seen in Table 3.

Table 3. Paired sample t-test results

Data	t	df	Sig.
Pretest - Posttest	-21.296	30	.000

The results of the paired sample t-test conducted using SPSS showed that the value of Sig. < 0.05, namely .000 < 0.05, then the decision was H1 accepted. This shows that there is a significant difference between the mean of the pretest and posttest results after being given PjBL-STEM treatment.

Then, to find out the magnitude of the improvement in problem-solving skills in students after being treated with the application of learning with PjBL-STEM, an N-Gain analysis was carried out. The following are the results of the analysis of the N-Gain calculation, which can be seen in Table 4.

Table 4. N-gain test results

Data	Pretest	Posttest	N-Gain
Mean	43,95	76,14	0,57

Table 4 shows that there is an increase in problem-solving abilities as indicated by the N-Gain score being in the medium category.

The pretest and posttest data obtained contained 4 indicators of problem-solving ability by Polya (1945), namely 1) understanding the problem, 2) planning a solution, 3) carrying out the plan, and 4) looking back. The questions consist of 12 questions in description form. These questions are then used to measure the magnitude of the increase in problem-solving abilities for each indicator. The results of these measurements are as follows.

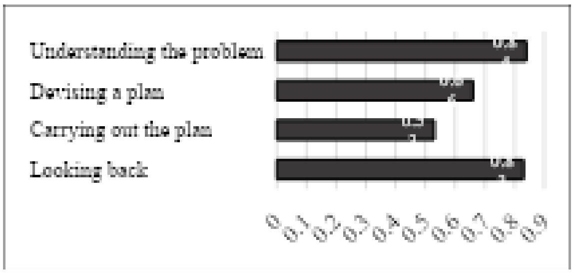

Figure 1. N-gain test Results for each indicator of problem-solving ability

The level of students' problem-solving abilities is obtained from the average results of the pretest and posttest, which have been carried out after implementing the disaster mitigation sub-material learning with PjBL-STEM. Analysis of the level of problem-solving ability is carried out for each indicator, namely understanding the problem, devising a plan, carrying out the plan, and looking back. The results of the analysis of the level of students' problem-solving abilities can be seen in Figure 2.

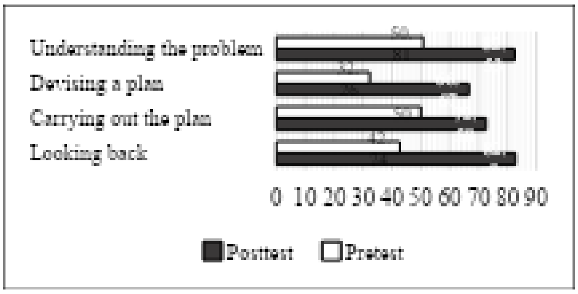

Figure 2. Average achievement of problem-solving ability for each indicator

Figure 2 shows that the average achievement of students' posttest scores in each indicator of problem-solving ability has exceeded the minimum limit determined in the research success indicators, namely, at least in the good category with a score of at least 60 or more.

Data from the pretest and posttest results of students' problem-solving abilities were then regrouped based on 4 indicators of problem-solving abilities, and level analysis was carried out on each indicator to determine the criteria achieved by students. A comparison of the percentages of the criteria for the level of students' problem-solving abilities based on the results of the posttest data is presented in Figure 3.

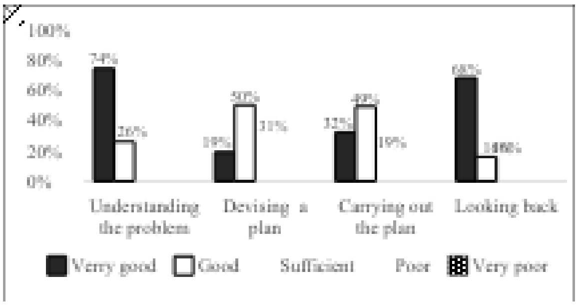

Figure 3. Achievement of problem-solving ability criteria for each indicator

Figure 3 shows that in the posttest results, very good and good criteria dominate each indicator. Meanwhile, a small portion is included in the sufficient criteria. This shows that the majority of students can be said to be good at identifying what is being questioned and determining the cause of a problem, estimating the strategy that will be used in solving the problem, applying the knowledge they have learned into problem-solving steps with a plan that has been prepared, and reviewing each problem-solving step or comparing the results with other methods (Febriani & Najibufahmi, 2022; Faseha et al., 2021; Astutui et al., 2020).

The level of problem-solving ability for each student as a whole is analyzed by looking for the average score of all indicators for each student. The results can be seen in Figure 4.

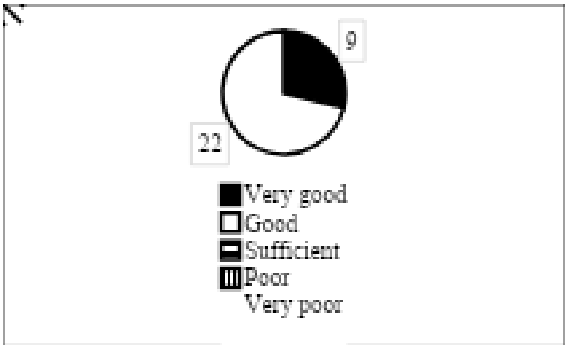

Figure 4. Level of students' problem-solving ability

The results showed that of the 31 students, there were 9 students who achieved very good criteria and 22 students who achieved good criteria.

In this study, a PjBL model is applied with a STEM approach that refers to the PjBL-STEM syntax developed by Laboy-Rush (2010), which consists of: (1) Reflection, students are led into the context of relevant problems, while being motivated to investigate and relate prior knowledge to what they will learn; (2) Research, students collaboratively gather information and develop ideas to find the right solution to the problem obtained; (3) Discovery, students collaboratively determine solutions to problems and are required to build a habit of mind from the design and design process; (4) Application, students test products/solutions in problem-solving for improvement of previous steps and connect STEM aspects; (5) Communication, students are asked to present products/solutions to their classmates, as well as constructive feedback interactions. The indicators of problem-solving ability can be enhanced when students are actively engaged in addressing problems and comprehend each stage of the problem-solving process (Aulia & Savitri, 2021).

Based on the results of the N-Gain test presented in Figure 1, understanding the problem indicator obtained an average increase in problem-solving ability in the high category. The increase in this indicator occurred because students in the learning syntax in the reflection phase were facilitated to understand the problem by relating the problem scenario obtained to events that occurred in real life, thus making the problem more relevant and easy to understand for students (Morrison et al., 2021; Pramesti et al., 2022; Karlina et al., 2023). This is in line with Afriana (2022), who stated that in the reflection phase, it is very clear how students are able to identify problems and provide alternative solutions. In this phase, students are given ill-defined problems through problem cards, which contain problem scenarios related to earthquake and landslide disasters that students will solve through project activities.

In the indicator of devising a plan, the average increase in problem-solving ability was obtained in the medium category. This increase in indicators is due to the implementation of the discovery and research phase, which encourages students to make detailed plans and consider various aspects of the solutions they will develop, so that they are familiar with a good planning process (Karlina et al., 2023). In the research phase, the teacher provokes students' ideas after reading the problem card and formulating the problem. Referring to Susanti et al. (2021), who stated that the focus of students in this phase is to plan a solution in the form of a product that can solve problems. Meanwhile, in the discovery phase, according to Pramesti et al. (2022), it is a link between the research phase and the knowledge gained during project preparation, where students here deepen the planning of previously prepared solutions and develop product designs. In this phase, students design product image designs with a design thinking approach. Referring to Wulandari et al. (2023), who explained that design thinking aims to hone students' ability to conceptualize ideas into visual forms.

Similar to the indicator of devising a plan, the indicator of carrying out the plan also obtained an average increase in problem-solving ability in the medium category. The increase in this indicator occurred because students in the learning syntax in the application phase were facilitated to be directly involved in the application of the products they developed, which required the application of concepts and their understanding (Morrison et al., 2021; Karlina et al., 2023). The focus of students in this phase is to make products that have been designed as solutions to problems obtained by applying the knowledge and data obtained in the previous stage (Pramesti et al., 2022).

The looking back indicator obtained an average increase in problem-solving skills in the high category. This increase in indicators is due to the fact that students test and evaluate their solutions, thus providing an opportunity to examine and improve the students' work. This is facilitated in the communication phase. In this phase, students get feedback from teachers and other students, thus helping them recognize mistakes and areas that need to be corrected or improved (Karlina et al., 2023). So that from in-depth review activities of every step in the project process, including the final evaluation of the solutions that have been implemented, it can train students' habits to critically review their work results (Helmi & Selaras, 2024).

The results of the analysis of the level of students' overall problem-solving ability, which can be seen in Figure 4, show that after the implementation of PjBL-STEM, most of the students are in the very good and good categories. This shows that most students have been able to solve problems according to the indicators of problem-solving ability. So that from this, after the application of PjBL-STEM in this study, students are considered to have been able to identify what is in question and determine the cause of a problem, estimate the strategies that will be used in solving the problem, apply the knowledge that has been learned into the steps to solve the problem with the plan that has been prepared, and review each step of solving the problem or compare the results with if other methods are applied.

CONCLUSION

Based on the results of research conducted at SMP Negeri 27 Semarang, the following conclusions were obtained; (1) There is a difference in problem solving ability between before and after the implementation of learning with PjBL-STEM in the disaster mitigation sub-material, (2) The level of students' problem-solving ability after the implementation of PjBL-STEM as a whole is at a good criterion. The level of students' problem-solving ability is highest in the indicator of understanding the problem, while the lowest level is in the indicator of devising a plan. Based on the conclusions obtained, the suggestions that can be given are; (1) For teachers, it is better to start integrating more problem-based learning designs, such as PjBL-STEM applied to this study or other problem-based learning designs, (2) For future researchers, it is better to provide clear boundaries to the product design that students design related to the STEM components that need to be raised, so that all STEM components are contained in the resulting product, (3) For future researchers, it is better to use 2 or more experimental classes as research samples in order to obtain more representative and comprehensive research results

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