The Effect of Project Based Learning Integrated STEM to Increase Science Process Skill

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Abstract *- This research aims to determine the effect of project-based learning integrated with the STEM method on the greenhouse effect and global warming on science process skills of class XI of the MIPA program in Senior High School in 9 Jakarta. This research is experimental research with two groups. Class control using discovery learning and class experiment using PJBL integrated with STEM. The instrument is a multiple-choice test with as many as 20 questions that use science process skills indicators. Analysis of this research data using the independent sample t-test was used to see the effect of the learning model on the science process skills, and the results obtained showed a significant effect. From the results of the analysis data, there is an effect of PjBL learning integrated STEM method to increase science process skills of students of class XI. Applying project-based learning integrated with STEM dramatically improves students' abilities, especially in observing, applying and conducting experiments. For the questionnaire students' responses to the implementation of the learning model, more than 80% of students were becoming more motivated in learning, more help understanding the subject matter, and could improve their problem-solving abilities.*

Keywords*: Project Based Learning; STEM; Science Process Skill.*

INTRODUCTION

To face the Industrial Revolution 4.0, we need human resources who can think, including logical reasoning, systematic thinking, critical thinking thoroughness, creativity, and the ability to communicate ideas, especially in solving problems. One of the efforts to improve human resources quality is education. The education system in Indonesia currently refers to the 2013 curriculum. The 2013 curriculum emphasizes scientific learning, where the learning process is designed very well and precisely so that students actively construct concepts, laws, or principles through scientific stages to provide meaningful and broad experiences to students because good learning of science must associate science with students' experiences and daily lives (Lazim, 2013).

The application of the 2013 curriculum encourages students to have scientific abilities, one of which is the science process skills. Science process skills are a complex set of abilities commonly used by scientists in conducting scientific investigations into a series of learning processes. Science process skills require students to use the senses to observe, classify, communicate what is known, measure, make temporary conclusions, and predict the possibility of results before actually experimenting (Kurniasari, 2017). However, students can only fully understand scientific ideas if they get involved in inquiry activities where those ideas can develop ideally (NRC, 2012).

Based on observations at SMAN 9 East Jakarta schools have implemented the 2013 curriculum, but the implementation is still rigid and conventional. The teacher who applies the learning models tends to emphasize the mastery of value-oriented concepts. Although at the beginning of the learning process teacher gives questions and problems, teaching and learning activities focus on taking notes and working to solve the questions without practising thinking skills. Students are only oriented towards grades, so the learning process about physics itself becomes meaningless and has no correlation with the real world. For this reason, a learning process allows students to find their knowledge through investigation activities and create projects to solve problems.

Project-based learning (PjBL) is a learning model that allows students to design and solve problems in a project, so students learn not only concepts but also scientific methods to solve these problems. Student learning experiences are built on the project-based learning process (Afriana, 2015). In PjBL learning, students are required to do a project. Before doing the projects, students must search for information, investigate, make assessments, and design the experimental tool.

Besides PjBL, learning models today must be able to follow current development by integrating Science, Technology, Engineering, and Mathematics (STEM) in the learning process. The STEM developed in the United States is an approach that combines the four disciplines in an integrated manner into the learning process. According to Brown et al. (2011), STEM is a meta-discipline at the school level, where science, technology, engineering, and mathematics teachers teach integrated approaches. Each material is not divided but handled and treated as a dynamic whole. STEM-based learning methods apply knowledge and skills together to solve a case. The relationship between science and technology and other knowledge cannot be separated from learning science. Science requires mathematics as a tool for processing data, while technology and engineering are applications of science (Afriana, 2015).

Project-based learning and STEM have complementary strengths and weaknesses. In project-based learning, students understand the concept by making products. At the same time, there is a design and redesign (engineering design process) process in the STEM method that makes students produce their best products. The integration of STEM aspects can positively impact learning, especially in terms of improving students' science process skills (Becker & Park, 2011).

The STEM-integrated project-based learning syntax termed the STEM PjBL consists of five steps: reflection, research, discovery, application, and communication. Each step aims to achieve a specific process (Laboy-Rush, 2010). Reflection aims to bring students into the context of the problem and provide inspiration so that they can immediately begin to investigate and connect what is known and what is learned. Research helps students gather relevant information in developing conceptual understanding. Discovery aims to develop students' abilities in building the habit of mind in the process of designing. The application aims to test products or find solutions to solve problems. Communication aims to present products or solutions within the scope of the class.

Suwarna et al. (2015) conducted a learning process based on STEM for science subject research using a balloon-powered car as a medium. In this STEM-based learning, students are asked to design a balloon-powered car as a medium to understand the concept of uniform linear motion. After learning, students are interviewed about their response, influence and understanding of learning activities. The results showed that the learning process based on STEM could increase motivation and provide experience in the manufacturing process.

Besides it, learning with STEM can increase student final exam scores.

Agustina et al. (2017) conducted another research on implementing STEM. Their research applies STEM to improve the ability to control variables, which is part of scientific reasoning abilities. Science reasoning is the ability students have to control variables. This competence is very much needed during the scientific investigation process. The results showed increased student control of variables after applying STEM in the learning process, with an N-gain value of 0.45 in the medium category.

The present research aims to find the best ways to help students to higher their science process skills. Specifically, the main research questions include: (1) are there any effects of learning project-based integrated STEM to increase students' science process skills, (2) how do students respond to the implementation of STEM-integrated project-based learning?

RESEARCH METHODS

In this study, the method used was quasi-experimental, using the two-control group pretest-posttest design. This research was conducted at SMA Negeri 9 Jakarta in the 2017/2018 school year. The population in this study were all students of class XI IPA, amounting to 4 classes. The sampling technique is purposive sampling, by setting unique characteristics by the research objectives, that is, the same cognitive level.

The instruments in this study consisted of tests and non-test. The test instrument is a science process skills test in the form of multiple-choice tests with five answer choices, including observing, classifying, interpreting, predicting, applying concepts, communicating and experimenting (Wati, 2016). The pretest was given to both classes before being given treatment to know the science process skill level in both classes. Then the experimental class is treated with the STEM-integrated project-based learning application, while the control class is treated with the discovery learning model. After both classes were given treatment, then given a posttest to see how much improvement in science process skills was experienced by students in both classes.

For non-test instruments, questionnaires were given to students to see their responses to the implementation of STEM-integrated project-based learning. The scope of student responses is divided into four indicators: increasing motivation, helping to understand the subject matter, improving problem-solving abilities and having the desire to reuse the model. The questionnaire consisted of 12 positive and negative statements and was measured using a Likert scale.

The analysis technique used in this study is the analysis of normality tests and homogeneity tests to determine whether the two samples are normally distributed and homogeneous. If the data does not fulfil one of the prerequisite tests, non-parametric statistics can be used. The hypothesis test used was a 2-tailed (two-tailed) t-test in this t-test using SPSS version 24 software with two independent samples t-tests. The two-variable t-test compares whether the two variables are the same or different (Sugiyono, 2013). To calculate how much an increase in science process skills after the implementation the STEM integrated project-based learning is obtained by calculating the average value of the normalized gain / N-gain (Hake, 1999).

RESULTS AND DISCUSSION

This study aims to examine differences in science process skills of experimental class students with the STEM integrated project-based learning and control class that use discovery learning models. Data on increasing the science process skills were obtained from the average pretest and posttest scores. The average score of the pretest, posttest and normalized gain the science process skills can be seen in Table 1.

Table 1. Average of score pretest, posttest, and normalized gain <g>

Group	Pretest	Posttest	Gain Score	Criteria
Experiment	63,17	77,17	0,38	Moderate
Control	63,67	67,80	0,11	Low

Table 1. shows the average scores of pretests, posttests, and normalized gain <g> science process skills achieved by students after implementing the STEM-integrated project-based learning. The average score of the initial tests (pretest) of students' science process skills before the treatment learning process in the experimental class was 63.17%, while in the control class, it was 63.67%. It shows that the science process skills of the experimental and control classes are almost the same. The average score of the final test (posttest) of students' science process skills after learning in the experimental class was 77.17%, while in the control class was 67.80%. There is an increase significantly in the experimental class. It is caused by implementing STEM-integrated project-based learning that can train students' science process skills. It is because PjBL learning and STEM train students' thinking skills. The average normalized gain score <g> of students' science process skills in the experimental class was 0.38, while in the control class was 0.11. If confirmed in the category of (Hake, 1999), the results of an increase in the experimental class in the moderate category and the control class in the low category.

Descriptions of Improvement in Every Aspect of Science Process Skills

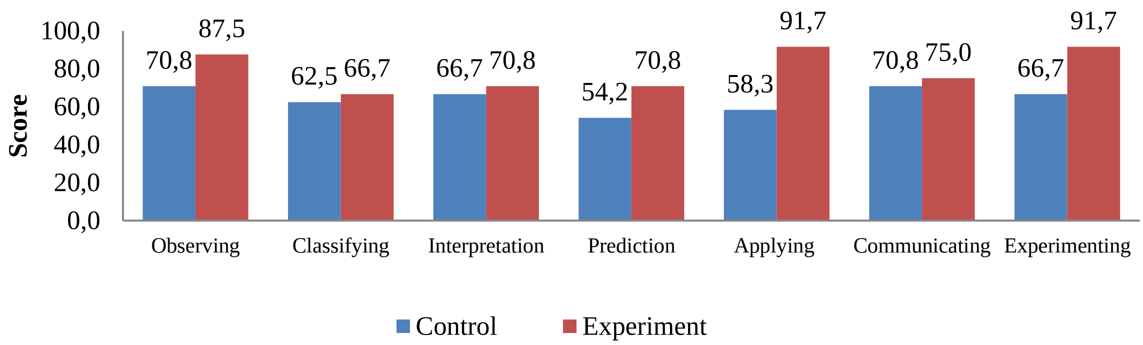

Figure 1. Average Student Score of Experiment Classes and Control Classes in Every Aspect of KPS

Figure 1 shows that the experimental class in every aspect of science process skill always increases more than the control class. The most notable increase in science process skills between the experimental and control classes is seen in applying the concept and planning the experiment. In both aspects, the experimental class's improvement was very significant. For applying the concept skills, the increase of students' abilities is very significant because the implementation of the STEM integrated project-based learning, students are required to apply their knowledge to design projects to solve problems given by the teacher presented in the form STEM-based worksheet. The more students understand the theme of the lesson, the more option solutions they will choose to solve the problem. Implementing STEM-integrated project-based learning also introduces engineering activities where students are asked to design or construct the most appropriate project to solve the problem. The subject of this study is the greenhouse effect and global warming. Engineering activities in the learning process and helping students improve academics also improve students' psychomotor skills.

Normality and homogeneity tests are performed with the help of SPSS for Windows version 24. The results for normality and homogeneity testing can be seen in Table 2.

Table 2. Test results for normality and homogeneity

<g>	N	Test Normality		Test Homogeneity	
		sig	Interpretation	sig	Interpretation
Experiment	36	0.07	Normal	0.339	Homogen
Control	36	0.06	Normal		

Based on table 2, it is known that the results of normality test data for science process skills using Kolmogorov-Smirnov with SPSS version 24 show that both data from the experimental and control class were normal because the calculation results obtained sig values more significant than the significance level of 0.05. For the homogeneity test using the Levene test, it is known that the data in the experimental class and the control class have the same or homogeneous variance. The significance value obtained by 0.449 is greater than the significance level of 0.05. Meanwhile, to determine a significant increase in science process skills is done by using a hypothesis test using the t-test. The results of the t-test can be seen in Table 3.

Table 3. T test results

Test Statictis 2 tailed		
Sig	α	Interpretation
0.00	0.05	Significant

Hypothesis test results obtained a significance level of 0.00. This significance level indicates a value smaller than 0.05, which means that at the level of confidence of 95%, STEM-integrated project-based learning can significantly improve students' science process skills in teaching materials on the greenhouse effect and global warming.

Student responses of the STEM integrated Project-Based Learning

Student responses to the STEM-integrated project-based learning questionnaire were conducted at the end of the learning. The questionnaire was

distributed to all study samples. The distribution of questionnaires aims to collect data on student responses to the learning model to obtain a tendency or direction of student attitudes after learning is completed in the experimental class.

The average percentage of students' responses to the STEM integrated project-based learning for the first indicator, learning motivation, 77.50% of students felt more motivated. Students answer if they prefer learning by doing and designing experiments rather than memorizing equations or propositions. For the second indicator, which helps understand the subject matter or theme, as much as 88.42% of students answered that they were greatly helped. Observing, classifying and planning experiments when learning helps students understand the lesson because they are not just reading what is in the book but are asked to make direct observations. This activity stimulates students to think and reason. For problem-solving indicators, students answer the activities of applying concepts, predicting and planning experiments, which are very helpful in problem-solving skills. After attending the STEM integrated project-based learning in class, more than 87.67% of students can be better able to solve problems related to daily life. They do not just count and use formulas. For the last indicator, as many as 81.03% of students wanted to follow back the implementation of the STEM-integrated project-based learning on another theme because they felt this learning activity was fun.

CONCLUSION

Based on the research and data analysis results, the increase of science process skill for the experimental class has a 0.38 normalized n-gain score, which is mean in the moderate category if confirmed by Hake. The control class has a 0.11 normalized n-gain score in the low category. That means implementing STEM-integrated project-based learning can significantly increase students' science process skills. The application of project-based learning integrated with STEM dramatically improves students' abilities, especially in the realm of observing, applying and conducting experiments

For the questionnaire students' responses to the implementation of the learning model, there were 77.50% of students became more motivated in learning, 88.42% of students were more helped in understanding the subject matter, 87.67% of students could improve their problem-solving abilities, and 81.03% wanted to repeat this learning model for different material.

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