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Project Based Learning (PjBL) Model with STEM Approach: Its Impact on Students Creative Thinking Skills on Energy in Living System Topic

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ABSTRACT
This research aims to determine the increase in creative thinking skills of secondary school students through the application of the PjBL model with a STEAM approach to energy materials in living systems. This research uses a true experimental method with a pretest-posttest control group design. The population of this study was all class VII students. The sample selection used a simple random sampling technique so that one experimental class was selected which applied the PjBL model with the STEAM approach and one control class which applied the conventional learning model. Data collection was carried out through creative thinking skills test questions and observation sheets. Posttest data on students' creative thinking skills were analyzed using the Mann-Whitney test, and observation sheets were analyzed using descriptive analysis. The results of the analysis using the N-gain test in the control class obtained a value of 47,4 in the medium category and the experimental class with an N-gain of 71 in the high category. It can be concluded that there is a significant increase in students' creative thinking skilss after learning using the PjBL model with the STEAM approach in learning Energy in Living Systems.

Keywords: *project based learning, steam, creative thinking skills, energy in living systems*

INTRODUCTION

The rapid development of technology has triggered a revolution in all aspects of our lives. Education has an important role in facing a future full of challenges and changes. Various efforts have been made in the field of education to develop and renew innovation in the 21st century. Efforts to develop skills appropriate for the 21st century are carried out by making curriculum changes. This change started with the national curriculum, then continued with the 2013 curriculum which is based on 21st century learning. Apart from that, this curriculum change is also expected to make education more creative, active, and make students think critically and not be left behind era (Dywan & Airlanda, 2020).

Based on Minister of Education and Culture Regulation Number 67 of 2013, the 2013 Curriculum is intended to prepare students to have the ability to live as individuals and citizens of the country who have faith, are useful, creative, innovative, and effective, and can contribute to the community, nation, state, and world civilization. In reality, there are still many students who lack

skills such as: (1) conducting research; (2) use of media, and procedures; (3) understanding complex information; (4) theory, analysis, and problem-solving (Fanani, 2018).

Therefore, the National Education Association(NEA) provides several suggestions to continue to strive for skills and development in the 21st century. What is recommended by the National Education Association (NEA) is (1) Critical thinking and problem solving, the ability to argue, think systematically, and be able to solve problems. (2) Communication, students can convey their ideas effectively in verbal and non-verbal forms, have listening skills, can use communication devices effectively and functionally, and can dialogue with different groups, for different purposes, and in different cultural contexts. different. (3) Collaboration, students can work together in a team, are flexible can help in discussions to achieve agreed goals, and have responsibility and appreciate the hard work of each group member. (4) Creativity and Innovation, is the ability to think creatively, work creatively with others, be able to implement creative ideas in practice(Junedi et al., 2020).

So far, it can be said that 21st century skills have been pursued in science learning. The science learning process has standards that refer to Minister of Education and Culture Regulation Number 65 of 2013, the process standards are detailed as criteria for implementing the learning process in educational units in achieving pass competency standards. Therefore, the learning process at every level of education is required to be planned well. In this way, the learning process can be conducted optimally, and assessment in learning can be directed at increasing the effectiveness and efficiency of achieving graduate competencies..

However, many problems arise in the field, such as educators not fully understanding the true meaning of science and also how to teach it in the classroom. In general, science teachers create science learning plans that are not in accordance with their essence. This results in students having wrong concepts, and also educators not paying attention to students' psychology from the beginning of learning to the end, and what happens is that science learning becomes less meaningful. Most science teachers have difficulty instilling curiosity about how and why natural phenomena arise. Apart from that, the application of learning methods is less than optimal, and choosing learning media that is appropriate to the material to be taught, and instilling verbalistic concepts feels difficult. (Lukum, 2015).

Based on interviews and observations that were carried out on April 7 2022 at one of the junior high schools in Pekanbaru, it was found several phenomena such as during the teaching and learning process educators focused more on mastering the material, and the use of varied learning models was rarely carried out by educators and students were required to carry out direct investigations through observation. In this way, students become passive during learning and this causes their creative thinking skills to become low. Many efforts have been made to improve students' creative thinking skills by using known learning methods and models, but the level of students' creative thinking is still very low. Apart from that, project creation is still rarely done, resulting in a lack of creative thinking skills. Creative thinking is very important, in Thailand creative thinking is an important feature of students' STEM learning and must be implemented through the educational community (Yuenyong, 2019).

With the problems explained previously, researchers are interested in implementing the PjBL learning model with the STEAM (science technology engineering art mathematics) approach. In PjBL students are asked to solve problems using all their abilities or potential. Project-based learning has the potential to enable students to research, plan, design, and reflect on the creation of technology projects(Doppelt, 2009). The activity of designing and creating a project will support the development of the potential of each student(Ardianti et al., 2017). Research conducted by (Fitriyah & Ramadani, 2021; Sari et al., 2017) shows that learning using the PjBL model can improve students' creative thinking skills. Apart from that, based on systematic literature review (SLR) research conducted by (Lestari & Ilhami, 2022) stated that the application of the PjBL model can improve students' creative thinking skills.

PjBL learning syntax developed by The George Lucas Educational Foundation (in Purnomo, Halim and Ilyas, 2019) consists of(1) start with the essential question (determine the basic question); (2) design a plan for the project (drawing up project planning); (3) create a schedule (arrange a schedule); (4) monitor the student and the progress of project (monitor students and project progress); (5) assess the outcome assess the results); and (6) evaluate the experience.

The PjBL model can be integrated with various approaches such as the STEM (science technology engineering mathematics) approach. STEAM as interdisciplinary combines several scientific disciplines under the same theme, but each scientific discipline remains separate (Thuneberg et al., 2017). The STEAM approach is learning that integrates various disciplines including science, technology, engineering, art, and mathematics with the aim that students can increase their creativity, innovation, problem-solving, student involvement, and benefits (Diana & Saputri, 2021). Miller et al., 2019 said that STEAM learning develops students' creativity or as a means to improve problem solving skills in the real world. STEAM as transdisciplinary includes the full integration of these various disciplines and its learning is rooted in authentic problems or investigations(Quigley, C., Herro, D., & Jamil, 2017). In the study conducted by (Annisa et al., 2019) The STEAM integrated project-based learning model shows results, namely that students can develop critical thinking skills and creative thinking skills, problem-solving, cooperation, and skills in opinion and responsibility. And according to research results Ahmad et al., (2021) It was explained that the learning method using STEAM in learning had a positive impact on learning where students experienced a significant average increase before and after being given learning using the STEAM method. Furthermore, learning using STEAM can develop creative thinking abilities by providing direct experience through the project work process.

The PjBL model focuses on problems so that it can motivate and encourage students to learn basic concepts and principles of knowledge directly through real-world experience. The combination of learning models and learning approaches certainly has great advantages and potential for strengthening students' creative thinking skills. The activities carried out in STEAM-PjBL learning refer to the project-based learning stages, which also have provisions that are integrated with STEAM aspects which include science, technology, engineering, art, and mathematics.

Science has a variety of materials, science learning has an important role in improving the quality of education and focusing on improving the quality of education, one of the science materials is energy in living systems. Energy in living systems is a very complete and dense material whose discussion includes kinetic energy, potential energy, heat energy, electrical energy, chemical energy, and nuclear energy. This research aims to find out through the application of the PjBL (Project Based Learning) model with STEAM.

METHODOLOGY

The research was carried out at one of the SMP in the city of Pekanbaru in the 2022/2023 academic year. The research used a true experimental design with a pretest-posttest control group design. The research population is class VII students. Learning uses 2 classes, namely the experimental class and the control class which have been selected using random sampling. The sample in this study was Class VII PA 1 with a total of 19 students and Class VII PA 2 with a total of 19 students. The experimental group is a group of students who receive learning by applying the PjBL model with the STEAM approach, while the control group is a group of students who receive learning using the conventional model. The two groups were given a pretest and posttest to see the increase in students' creative thinking skills between before and after learning.

Table 1. Research Design Model

Group	*Pretest*	*Treatment*	*Posttest*
Experiment	O_1	X	O_2
Control	O_3		O_4

Source:(Sugiyono, 2019)

X = Treatment with the PjBL model with a STEAM approach
O_1 = Pretest experimental class
O_2 = Posttest experimental class
O_3 = Pretest control class
O_4 = Posttest control class

The instrument used in this research is a creative thinking test in the form of questions about energy in living systems in the form of an essay with 15 questions with four indicators of creative thinking, namely fluency, flexibility, originality and elaboration. There are 4 questions with fluency indicators, 3 questions with flexibility indicators, 4 questions with originality indicators, and 4 questions with elaboration indicators.

Testing the validity of the creative thinking test instrument questions in this research was carried out through content validity by asking for judgment from lecturers/experts. The creative thinking test instrument in this research was validated by 2 people. The increase in students' creative thinking skills after participating in learning by implementing the PjBL model with the STEAM approach is calculated based on the gain score which is normalized using the formula developed by (Hake, 1998), that is:

$$<g> = \frac{<S_{post}> - <S_{pre}>}{S_{m\,ideal} - <S_{pre}>} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Information:

G = normalized average gain score
S_{post} = the average score of the final test obtained by students
S_{pre} = the average initial test score obtained by students
$S_{m\,ideal}$ = ideal maximum score

Table 2. N-Gain Score Category

Value<g>	**Value Percentage <g>**	**Criteria**
<g>≥0.7	<g>≥70	Tall
0.3≤<g>< 0.7	30≤<g>< 70	Currently
<g><0.3	<g><03	Low

Source :(Reynawati et al., 2018)

Apart from creative thinking test instruments, there are also non-test instruments in the form of observation sheets. Observation sheets are used to determine the implementation of learning using a project-based learning model with a STEAM approach through student activities and teacher assessments based on observed learning activities.

Hypothesis testing is carried out using the independent sample t-test with the prerequisites for the data being tested to be homogeneous and normally distributed data. If the data is not normal then the test carried out is the Man Whitney test. The data processing flow to test hypotheses regarding the application of the PjBL learning model with the STEAM approach to improving creative thinking skills on energy materials in living systems is shown in Figure 1.

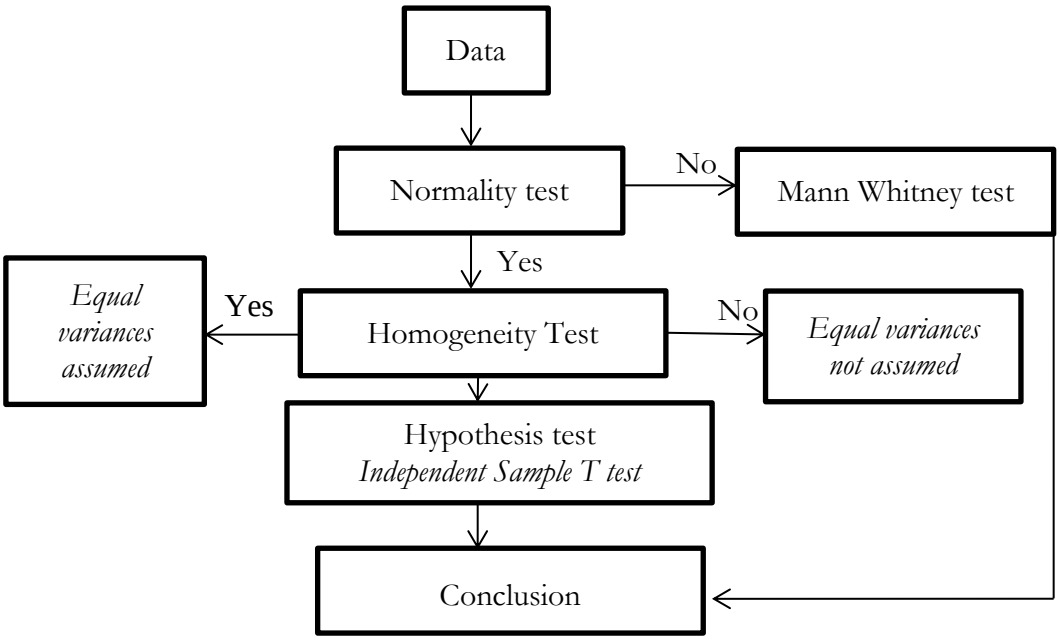

Figure 1. Hypothesis Testing Flow (Permana, 2018)

RESULTS AND DISCUSSION

This research was carried out over 3 meetings with the material being taught, namely energy in living systems in the experimental class and control class, 3 meetings each, 1 pretest to determine students' initial knowledge, and 1 post-test to determine the influence of the PjBL model with the STEAM approach to students' creative thinking skills after being given PjBL model treatment with the STEAM approach. The following is figure 2, a diagram of the results of implementing the PjBL model using the STEAM approach which has been observed by the observe.

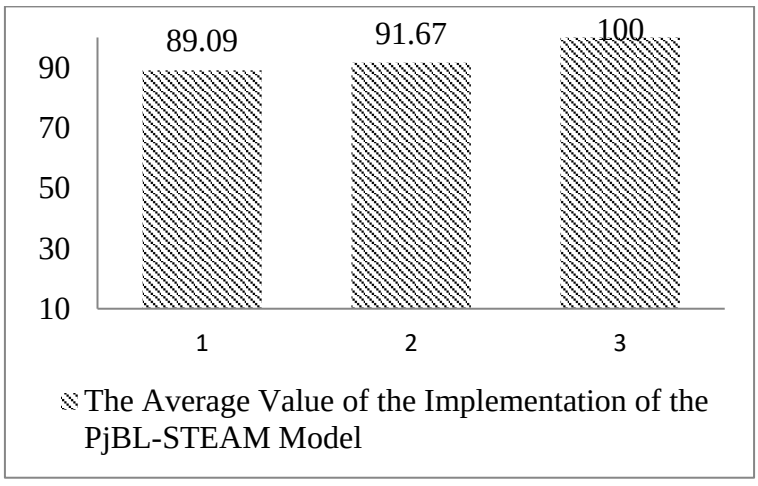

Figure 2. Teacher Activity Observation Sheet Diagram

At the first meeting, the implementation of the PjBL model with the STEAM approach carried out by the researcher as a teacher during the learning process obtained an average score of 89.09 in the category of not running smoothly in the basic question syntax. At the second meeting, the implementation of the learning model carried out by educators experienced an increase of 91.67 with the category not running smoothly in basic question syntax and preparing a project completion schedule. At the third meeting, the implementation of the learning model carried out by educators

had improved, namely with an average score of 100, all phases ran smoothly because educators were used to it and evaluated the mistakes made at the first and second meetings.

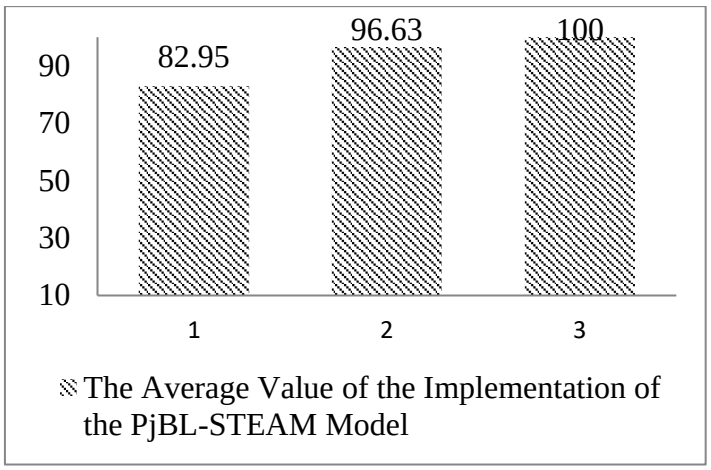

Figure 3. Student Activity Observation Sheet Diagram

The first meeting held by the students also did not go smoothly with an average implementation of the learning model of 82.95 with the category not running smoothly in the basic question syntax where according to observers there were still many students who did not pay attention to the video being shown, causing students to not responded, apart from that, in the project design phase there were still many students who did not work together, listened to the directions given by the educators and in completing the project each group needed more time than the time agreed upon and in project presentations, there were still many students who were not seriously in carrying out the project presentation. At the second meeting, the implementation of learning using the project-based learning model with the STEAM approach carried out by students was 96.63, categorized as all activities carried out, the learning syntax which was not smooth was found in the project design syntax and student project monitoring. At the third meeting, the implementation of the learning model carried out by students was 100, both categorized as all activities carried out and all learning syntax running smoothly because they were used to learning using the PjBL model with the STEAM approach.

Based on the results of data analysis and processing of the average scores of pretest, posttest, and normalized gain of students' creative thinking skills in the experimental class and control class, the results of the comparison of scores obtained in the experimental class and control class can be presented in the following figure.

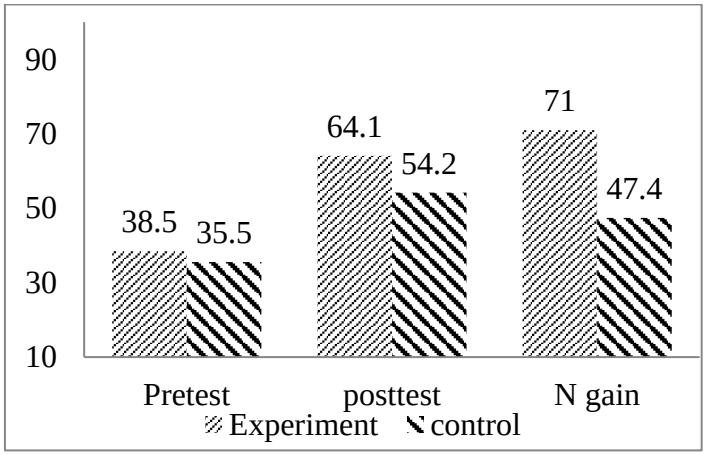

Figure 4. Graph of comparison of average pretest, posttest and normalized gain scores for students' creative thinking skills

Based on the graph above, it is known that the average pretest score for creative thinking skills of students in the experimental class and control class shows no significant difference, for the experimental class the score was 38.5 and the control class got an average score of 35.5. For the average posttest score of students' creative thinking skills between the experimental class and the control class, there was quite a significant difference, the experimental class got an average score of 64.1 and the control class got an average score of 54.2. There was an increase in students' creative thinking skills as seen from the normalized average grain score. The average gain score that has been normalized for students' creative thinking skills in the experimental class is 71 in the high category. Thus, it shows that students' creative thinking skills increase after following the learning process using the PjBL model with the STEAM approach. Meanwhile, the dick class obtained a normalized average gain value of 47.4 in the medium category.

The indicators of creative thinking skills whose improvement is measured are fluency, flexibility, originality, and elaboration. A summary of the comparison of average scores for each aspect of creative thinking skills in the experimental class and control class can be seen in the following figure.

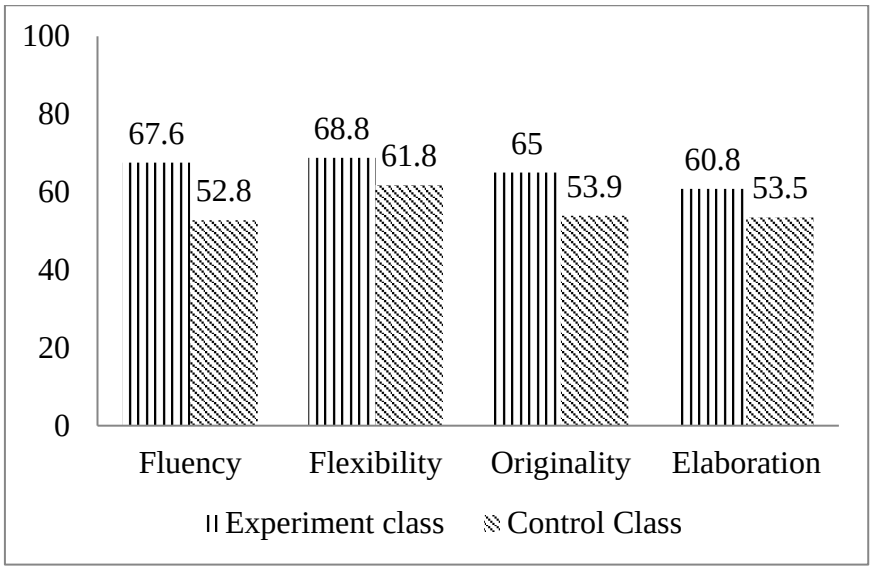

Figure 5. Comparison graph of the average value of each indicator of creative thinking skills

Based on the graph in Figure 5, it is known that the mean value of each indicator in the experimental and control groups shows significant differences. In the experimental class, the average value for the fluency indicator was 67.8, the flexibility indicator was 68.8, the originality indicator was 65, and the elaboration indicator was 60.8. Meanwhile, in the control class, the average value for the fluency indicator was 52.8, the flexibility indicator was 61.8, the originality indicator was 53.9, and the elaboration indicator was 53.5. So it can be concluded that there are differences between the experimental and control classes learning about energy in living systems.

Furthermore, to find out whether the project-based learning model affects students' creative thinking skills or not, a normality and homogeneity test analysis was carried out on the students' post-test results and the significant value (sig) for the experimental class and control class using the normality test can be determined. Shapiro-Wilk. In the experimental class, the posttest significant value (sig) was $0.011 < 0.05$ and in the control class, the posttest significant value (sig) was $0.175 > 0.05$, so it can be concluded that the data was normally distributed in the control class and abnormally distributed in the experimental class. After carrying out normality and homogeneity tests on the posttest scores, it was concluded that the data in the experimental class was not normally distributed and had homogeneous data variance. So the next step is to carry out the Mann-Whitney Test (U-Test).

Table 3. Mann-Whitney test

	Mark
Mann-Whitney U	62,500
Wilcoxon W	252,500
Z	-3,451
asymp. Sig. (2-tailed)	001
Exact Sig. [2(1-tailed Sig.)]*	.000b
a. Grouping Variables: Class	
b. Not corrected for ties.	

The Mann-Whitney test has been carried out so it is known that the calculated Z is -3.451 with a sig value of 0.001. The significance value is smaller than 0.05 so based on the decision-making criteria H0 is rejected and Ha is accepted. So it can be concluded that there is a significant difference in increasing creative thinking skills between students who receive learning using the PjBL model with STEAM and students who receive learning using the conventional model on energy in living systems in class VII.

There has been an increase in students' creative thinking skills due to the implementation of the PjBL learning model with the STEAM approach which at the learning stage trains students to develop creative thinking skills. In line with the results of this research, research conducted by Lestari (2021) states that the PjBL integrated STEAM approach can develop 21st-century skills, namely being able to create students who have critical thinking, can create solutions to existing problems, are creative and innovative, have good communication and cooperation, information literacy, media literacy, technology literacy, flexibility, and adaptability.

Apart from that, research conducted by Suryaningsih & Ainun (2021) with the title The Contribution of STEAM Project Based Learning in Measuring Students' Science Process Skills and Creative Thinking. It can be concluded that the research shows positive results, with students' creative thinking skills getting a score of 4.134 and a percentage in the high category, namely 82.7%. STEAM-PjBL learning received a positive response. And research conducted by Fitriyah & Ramadani (2021) with the title The Influence of PjBL-Based STEAM Learning on Creative and Critical Thinking Skills it can be said that PjBL-based STEAM learning has a significant influence on students creative thinking skills, as shown by sig. of Fcount is 35.551 and is 0.000 smaller than 0.05. Apart from that, research results from Prajoko et al., (2023) State that the model with STEM This approach influences students' conceptual understanding and creativity.

The problem in this research is the students' limited time to complete the projects assigned to them. Therefore, it is recommended for further research to make the time and projects carried out more effective and efficient. Further research can be carried out by adding variables such as using PjBL integrated STEAM-ESD to improve students' creative thinking.

CONCLUSION

Based on the research results, it was concluded that the results of the N-gain test in the control class obtained a value of 47,4 in the medium category and the experimental class with an N-gain of 71 in the high category. Thus, it can be concluded that there is a significant increase in students' creative thinking skills after learning using the PjBL model with the STEAM approach in learning Energy in Living Systems.

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