



Effectiveness of Project Based Learning Low Carbon STEM and Discovery Learning to Improve Creative Thinking Skills

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Abstract: Integrating low-carbon or environmentally friendly principles into the learning process is possible, especially in the Project-Based Learning-Science Technological Engineering and Mathematics (PjBL-STEM) model. This study aims to determine the difference in effectiveness between PjBL-Low Carbon STEM and discovery learning to develop the creative thinking abilities of class IX students at one of Surakarta's public junior high schools and educate them about electricity and to know the application of the low carbon concept. This research is a quasi-experimental research type. The research design used in this study is the Pretest-Posttest Control Group Design, where the experimental class applies PjBL-Low Carbon STEM, and the control class applies discovery learning. The population in this study were all grade IX students. The sample in this study was class IX A as the experimental class and class IX B as the control class. The sampling technique used random cluster sampling. The data collection technique used a test of creative thinking skills description and student response questionnaires. The hypothesis test used is the t-test (t-test). This study concludes that there are differences in the effectiveness of PjBL-Low Carbon STEM and discovery learning to improve the creative thinking skills of class IX students on electrical materials. Applying the low carbon concept in the learning process can improve students' understanding of common carbon principles, concepts, and attitudes.

Keywords: PjBL-STEM, low carbon, creative thinking skills

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INTRODUCTION

Rapid technological breakthroughs and endeavors to address knowledge-based requirements define the twenty-first century. Human resources in the twenty-first century must possess a variety of skills and competencies in order to compete in the globalization era. Developing abilities and competencies in the twenty-first century is about acquiring skills and progressing. Creative thinking skills are one of the skills and competencies that must be developed (21st Century Partnership Learning Framework). Creative thinking skills are the capacity to communicate multiple ideas through questions and responses in learning activities—these skills are developed through meaningful activities that hone creative and analytical thinking (Buntat et al., 2011). Students' capacity to solve issues argue against facts, and complete assigned tasks demonstrate their capacity for creative thinking (Erdem & Adiguzel, 2019). According to Piirto (2011), creative thinking can be accomplished by utilizing various approaches to generate ideas, developing new and valuable ideas, and developing, refining, analyzing, and evaluating ideas to increase and maximize creative efforts. Creative thinking encompasses multiple critical components, including originality, adaptability, fluency, elaboration, and evaluation (Rahayu et al., 2011). Education can facilitate the transition to meaningful activity and serves to build a workforce and a mechanism for social control in order for society to grow sustainably (Sujana, 2019). Education must integrate creative thinking, cooperation, communication, and critical thinking to appropriately educate pupils for the future (Bedir, 2019).

The concept of sustainability is a crucial tenet of national education development. Education for sustainable development benefits students' futures by educating them about various issues, including social, environmental, and economic issues (Pauw et al., 2015). It also teaches individuals to act sustainably by educating them about various issues, including social, environmental, and economic issues (Gunamantha, 2010). Numerous environmental challenges are gaining attention at the moment, one of which is global warming, causing climatic uncertainty in some countries. Global warming is a critical issue to address to ensure the sustainability of nature, and if left unchecked, the impact will be detrimental to nature. Education can help mitigate the effects of global warming. Indonesia has promoted education for sustainable development by incorporating the problem of global warming into electrical materials. Low-carbon education can complement education for sustainable development (Permanasari et al., 2020). Low carbon is an individual's capacity to comprehend environmental phenomena and then take appropriate activities and

decisions to improve the environment and ensure nature's sustainability (Amin et al., 2020).

Students' future success is contingent upon their capacity for creative thought, as these qualities are closely related to daily life. As a result, students must demonstrate advanced ability in creative thinking. Developing pupils' creative thinking abilities continues to face hurdles, resulting in their poor accomplishment levels (Handayani et al., 2021). Firdaus et al. (2018) also reported similar findings, indicating that creative thinking skills at the junior high school level in biology learning in a sufficient category. Numerous variables contribute to students' lack of creative thinking abilities, including learning models, technology, techniques, and learning methodologies (Heriyanto et al., 2020). The correct approach, one of which is the PjBL-STEM paradigm, can allow pupils to enhance their creative thinking skills (Baran et al., 2021). PjBL-STEM is a collaborative learning model because it emphasizes the importance of participants becoming more engaged in learning activities and groups and sharing knowledge to assist students in opening up other knowledge during the thinking process (Ralph, 2011). This paradigm engages students in relevant learning activities by studying life concepts (Kristiani et al., 2017). Through reading, writing, observing, and working on projects that can be used to address problems, PjBL-STEM teaches children to think scientifically and builds a process of technical literacy (Lestari et al., 2018). PjBL-Low Carbon employs five-step process: (1) Reflection, (2) Research, (3) Discovery, (4) Application, and (5) Communication. The reflection step introduces pupils to the subject through films or worksheet tasks. Students conduct discussions and generate relevant concepts to answer the challenge throughout the research phase. The discovery stage serves as a link between the research process and the knowledge acquired during project preparation. The application stage tries to use the data acquired to solve problems through the conduct of experiments based on the ideas created. The final stage is communication, during which students present their experimental findings to other groups. The projects undertaken by students as part of their learning using the PjBL-Low Carbon STEM paradigm are environmentally friendly or low carbon in nature. Based on 3.5 grade 9 fundamental competencies, i.e. applying the concepts of electric circuits, alternative electrical energy, and sources of electrical energy in daily life, including alternative sources of electrical energy and various efforts to conserve electrical energy.

The development of 21st-century skills, especially creative thinking skills and sustainable concepts related to environmental issues, is the primary goal of national education. One way to develop creative thinking skills and apply the concept of sustainability can be done by applying the PjBL-Low Carbon STEM learning model. This model requires students to design and carry out projects in groups, which can help students develop their thinking skills through scientific activities. In addition, the concept of environmentally friendly or low carbon is one of the mandatory activities that must be applied in learning to support sustainable education. Based on the background of the problem, this study aims to determine the difference in effectiveness between PjBL-Low Carbon STEM and discovery learning to improve the creative thinking skills of class IX students at one of the public junior high schools in Surakarta in electricity and to know the application of the low carbon concept. PjBL-Low Carbon STEM is expected to be an alternative to improve creative thinking skills also add insight to students about the importance of low-carbon emission behavior to realize education for sustainable development.

METHODS

This research is a quasi-experimental research design in which the researcher only has partial or no control over the assignment to research subjects at the level of manipulated variables (Creswell & Creswell, 2018). The study used a Pretest-Posttest Control Group Design in which two classes were given a pretest to determine the initial conditions, and then a posttest was given to determine the difference between the two classes. The population in the study was class IX students at one of the public junior high schools in Surakarta in the 2021/2022 academic year, while the research sample was taken using the cluster random sampling technique and obtained two classes as the control class and the experimental class.

The instruments used are learning tools and tests to measure creative thinking skills and a questionnaire to determine student responses. The test used to measure creative thinking skills is a description test which consists of six questions. Before being used for research, the instrument was tested for validity, reliability test, discriminatory power test, and difficulty level. In this study, tests were used to collect data on creative thinking skills in pretest and posttest. The test instruments used were arranged based on aspects of creative thinking, namely fluency, flexibility, and originality. Tables 1 and 2 contain indicators for the questions.

Table 1. Indicators of Creative Thinking Skills on Pretest

Aspects of creative thinking skills	Indicators of Creative Thinking Skills	Question Indicator
<i>Fluency</i>	Seeing the weaknesses and faults of the situation or object	Criticizing the errors in electric field lines Investigating faults with the electroscope
<i>Flexibility</i>	Applying concepts in a different way	Calculate the magnitude of the electric potential difference Calculating the magnitude of the electric force
<i>Originality</i>	Have a solution to a problem	Predicting the process of changing the charge on an object Predict the step to increase the electric force

The indicators for the pretest of creative thinking skills on static electricity are listed in Table 1. Six questions assess fluency, flexibility, and originality in creative thinking. The pretest questions were provided prior to the treatment, and the post-test questions were delivered following the treatment, using static and dynamic electricity material. The post-test has six questions that assess fluency, flexibility, and originality. Table 2 contains indicators of post-test inquiries.

Table 2. Indicators of the posttest of creative thinking skills

Aspects of creative thinking skills	Indicators of Creative Thinking Skills	Question Indicator
<i>Fluency</i>	Thinking of more than one answer Fluent in expressing ideas	Give examples of alternative sources of electrical energy Identify the process of electric current flow
<i>Flexibility</i>	Applying concepts in a different way Giving interpretation to an image Have a solution to a problem	Calculating carbon emissions resulting from the use of electricity in an area Implement efforts to save electrical energy Predicting the type of electric charge through an electroscope
<i>Originality</i>	Thinking of more than one answer	Analyzing the steps for changing the charge on an object

Table 2 shows the post-test indicators for creative thinking skills on static and dynamic electricity. The value of creative thinking skills was then analyzed using the t-test (t-test) and improvement test (n-gain) to determine the difference in the value of creative thinking skills between the control class and the experimental class. Before testing the hypothesis (t-test), the value data were first tested for prerequisites using normality and homogeneity tests with the help of the SPSS 26 program with a significance level of 0.05. In the normality test of pretest and post-test values, the probability value of all pretest and post-test data values is more significant than 0.050, so the test decision is H_0 is accepted. The conclusion is that all pretest and post-test data are typically distributed. While the results of the homogeneity test calculation, the results of the pretest and post-test p-values are more significant than 0.050, namely, for the pretest, the p-value is 0.329, and for the post-test, the p-value is 0.556. The test decision is H_0 is accepted, so the conclusion is that the pretest and post-test values of creative thinking skills have homogeneous variances.

Research hypothesis: H_0 states that the discovery learning model effectively improves creative thinking skills, while H_1 states that the PjBL-Low Carbon STEM model is effective for improving creative thinking skills. Hypothesis testing using the SPSS 26 program uses a significance level of 5%. The test decision is the value of Sig. < 0.050, then H_0 is rejected, meaning that the PjBL-Low Carbon STEM model effectively improves students' creative thinking skills.

RESULT AND DISCUSSION

Creative thinking skills were measured using two tests, namely pretest and post-test, using six questions. Questions are given to the control class and the experimental class, the results of creative thinking skills are calculated based on the assessment rubric prepared. The pretest score in the control class obtained an average of 70.71, while the experimental class obtained an average of 75.13. The post-test value in the

control class was 76.35 and in the experimental class was 82.09. The minimum pretest value in the control class and experimental class is 54, while the maximum pretest value in the control class is 93, while the experimental class gets a maximum score of 89. In the post-test score, the minimum score in the control class is 64, while in the experimental class 68. The maximum post-test value is in the control class. The control class is 93, and the experimental class's maximum post-test score is 96. The pretest and post-test results show a difference between PjBL-Low Carbon STEM and discovery learning to improve students' creative thinking skills. PjBL-Low Carbon STEM is more effective than discovery learning because this model requires students to design a project to solve a given problem.

Question number 3 relates to the aspect of fluency, namely thinking about more than one different answer. The problem presented in the question is in the form of a depleting energy source, then students are asked to write answers about alternative sources of electrical energy derived from bioenergy. The comparison of the answers to question number 3 with the lowest scores in the experimental and control class is presented in Figure 1.

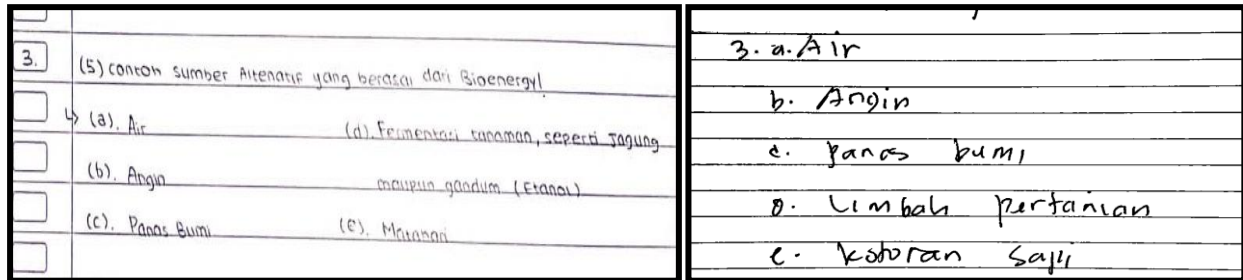


Figure 1. Example of Answers to Question Number 3 with the Lowest Scores in the Control Class (left) and the Experiment Class (right)

Figure 1 illustrates the responses to question 3 in the control and experimental classes with the lowest possible score of 2, indicating that approximately 3% of students in each class had the lowest score. Simultaneously, examples of student responses with the highest scores are shown in Figure 2.

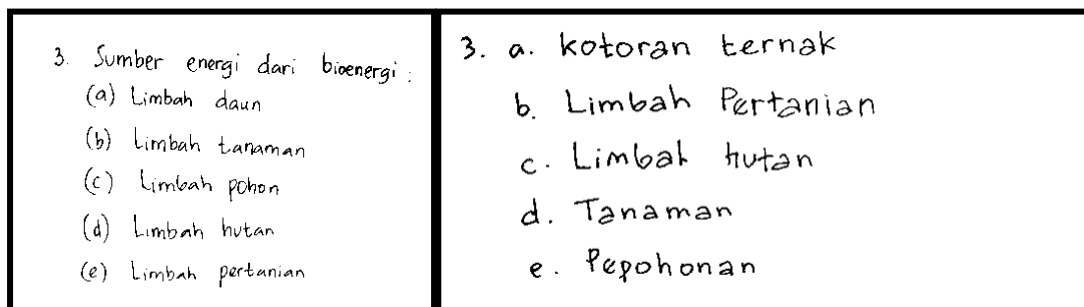


Figure 2. Example of Answers to Question Number 3 with the Highest Score in the Control Class (left) and the Experiment Class (right)

Figure 2 shows students' answers with the highest scores in the control class and the experimental class. The highest score obtained in control and experimental classes was 5. As many as 23% of students from the control class got the highest score, while in the experimental class, it was 28%. These results indicate that many students get high scores on the fluency aspect following the research of Jumi et al. (2018), which states that the highest aspect obtained by students in creative thinking skills is the fluency aspect. The number of students who get high scores on the fluency aspect is because, generally, students already can generate many ideas or ideas generated from their thoughts quickly (Firdaus et al., 2018). Some students have understood the example of bioenergy which is one of the alternative energy sources, and students still have difficulty distinguishing between alternative energy sources and alternative energy sources derived from bioenergy. Question number 3 is a question to measure the aspect of fluency; students are asked to mention more than one answer. Fluent thinking includes a person's ability to express several ideas and always provides many ways to do many things (Mulhayatiah, 2015).

Question number 4 relates to the fluency aspect, where the indicator of the question is that students are fluent in expressing ideas. The problem given is about how the lights can turn on, then students are asked to express their ideas regarding the process can turn on the lights. The comparison of the answers to question number 4 with the lowest scores in the experimental and control class is presented in Figure 3.

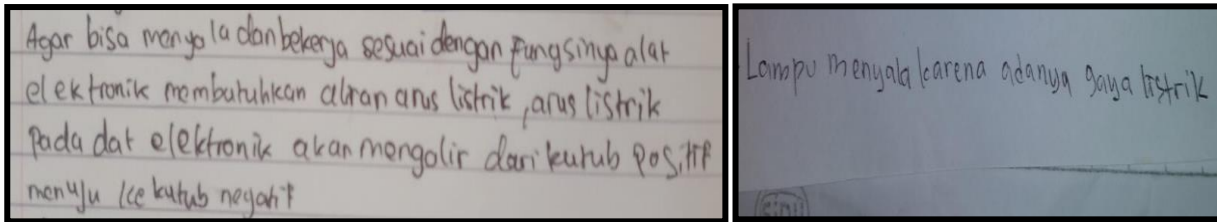


Figure 3. Example of Answers to Question Number 4 with the Lowest Scores in the Control Class (left) and Experiment Class (right)

Figure 3 shows the answers to question number 4 with the lowest scores in the control and experimental classes. In the control and experimental classes, the lowest score obtained by students was 2. 9% of students from the experimental class got the lowest score and 39% in the control class. At the same time, examples of student answers with the highest scores can be seen in Figure 4.

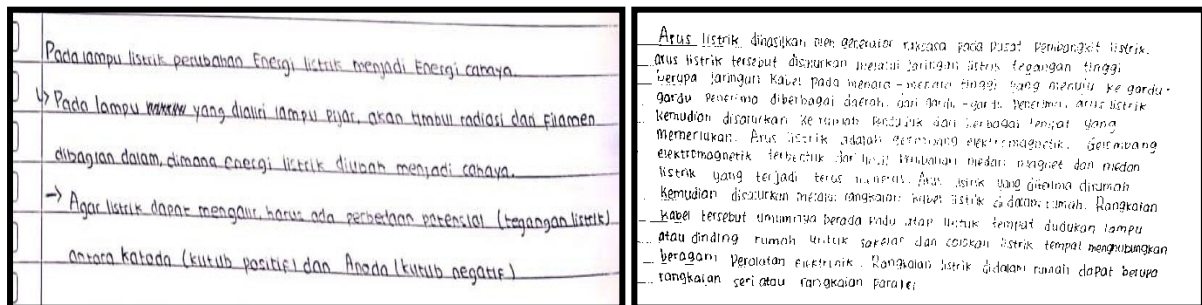


Figure 4. Example of Answers to Question Number 4 with the Highest Score in the Control Class (left) and the Experiment Class (right)

Figure 4 shows students' answers with the highest scores in the control class and the experimental class. The highest score obtained by students in question number 4, which measures the fluency aspect, is 4. A total of 56% of students from the experimental class got the highest score, while in the control class, only 6%. Based on the answers written by students, they still have difficulty expressing ideas related to how electricity can turn on lights. However, students already know the direction of the flow of electric current, namely from the positive pole to the negative pole. One indicator of fluent thinking is that students are fluent in expressing their ideas (Hasibuan & Hufri, 2018).

Questions 5 and 6 measure the aspect of flexible thinking, where the indicator of flexible thinking is applying concepts in different ways. In question number 5, students are asked to calculate carbon emissions from a village. The comparison of the answers to question number 5 with the lowest scores in the experimental and control class is presented in Figure 5.

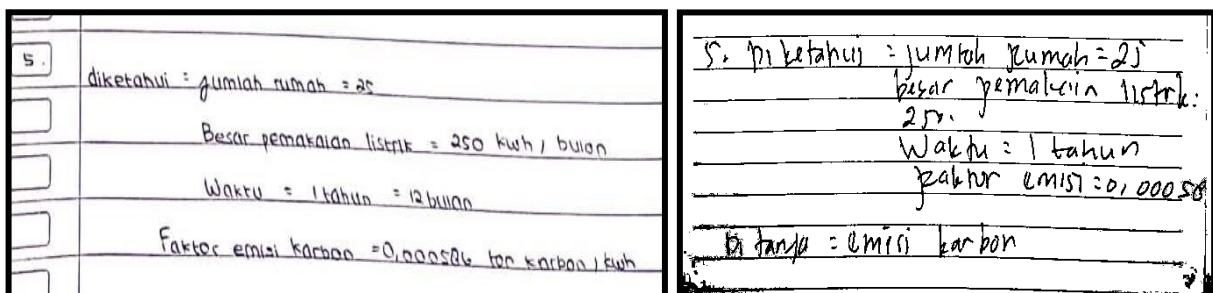


Figure 5. Example of Answers to Question Number 5 with the Lowest Scores in the Control Class (left) and Experiment Class (right)

Figure 5 compares the answers to question number 5 with the lowest scores in the control class and the experimental class. In the control class, the lowest score obtained by students is five, while in the experimental class, the lowest score is 4. As many as 23% of students in the control class got the lowest score on question number 5, and only 3% of students in the experimental class scored got the lowest. In contrast, examples of student answers with the highest scores can be seen in Figure 6.

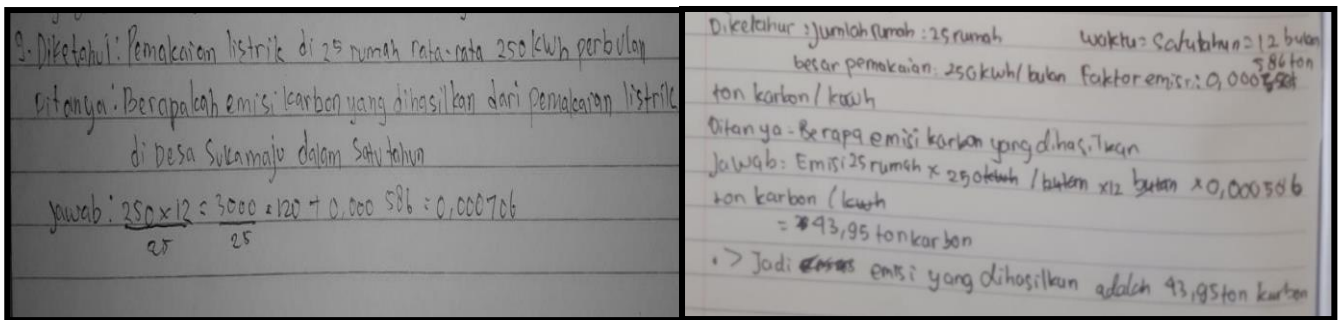


Figure 6. Example of Answers to Question Number 5 with the Highest Score in Control Class (left) and Experiment Class (right)

Figure 6 shows students' answers with the highest scores in the control class and the experimental class. The highest score for the control class was 6, with a percentage of 6% who got that score. While in the experimental class, as many as 6% of students got the highest score of 8. The low number of students who scored high on the flexibility aspect illustrates the weak ability of students to see or consider things from various points of view (Firdaus et al., 2018). On questions with flexibility, only a few students got high scores because some students were incomplete in providing answers or completing questions, following the research of Jumi et al. (2018). Based on the analysis of the answers given by the students, some of the students still have difficulty calculating the number of carbon emissions produced by a village, and this is because this carbon emission material is a new material for students. So that some of the students just wrote the questions without answering. Question number 5 relates to the flexible thinking aspect: applying a concept differently. One of the students' behaviours that shows the flexible thinking aspect is that when given a problem, students will think of various ways to solve it (Hasibuan & Hufri, 2018).

Question number 6, students are asked to write down the efforts that have been applied in everyday life to save electrical energy. A comparison of the answers of the experimental class and control class students on question number 6 can be seen in Figure 7.

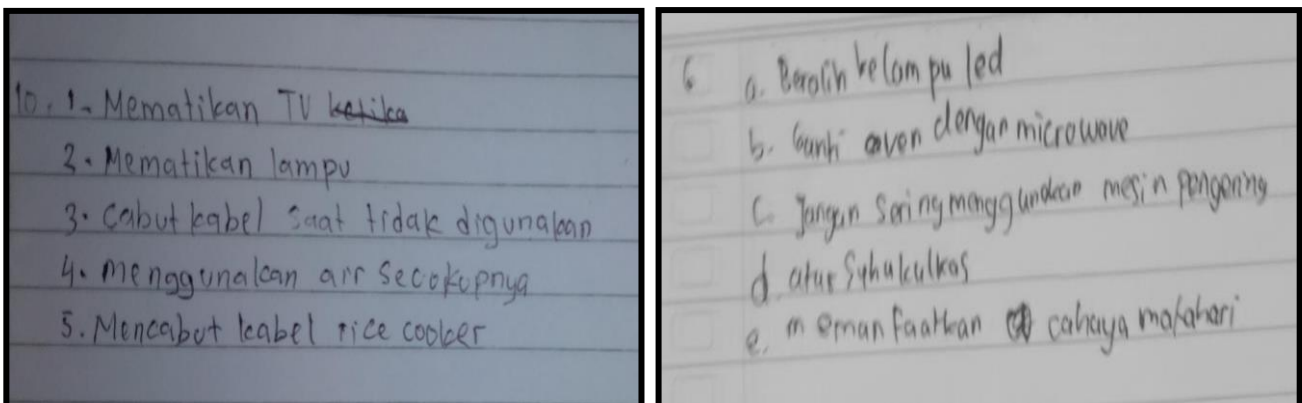


Figure 7. Example of Answers to Question Number 6 with the Lowest Scores in the Control Class (left) and Experiment Class (right)

Figure 7 compares the answers to question number 6, which measures the flexibility aspect with the lowest score. As many as 10% of control class students got the lowest score 2. Meanwhile, in the experimental class, 16% of students got the lowest score of 3. An example of student's answers with the highest scores can be seen in Figure 8.

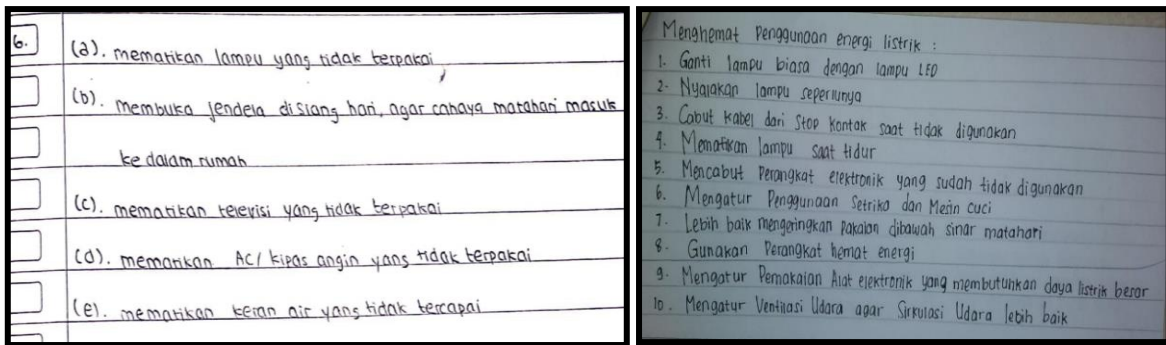


Figure 8. Example of Answers to Question Number 6 with the Highest Score in Control Class (left) and Experiment Class (right)

Figure 8 shows the answer to question number 6; the highest score obtained by students in the control class and the experimental class was 5. As much as 10% of the control class students got the highest score, while in the experimental class, it was 34%. Based on the analysis of the answers written by students, actually, students have written down the steps they have taken to save electricity use at home, but some students did not write down the five attempts that had been made and only wrote two or three steps. In addition, based on students' answers, it can also be seen that they have implemented different efforts with the same goal, namely to save electrical energy. This result follows the flexible thinking indicator that students can produce varied answers (Ekawati & Adirakasiwi, 2019).

Question number 2 relates to the aspect of flexible thinking, the indicator of flexible thinking is to give an interpretation of an image. Students are asked to interpret the electroscopes drawings and give names to the appropriate types of charge. The comparison of the answers of the experimental class and control class students on question number 2 can be seen in Figure 9.

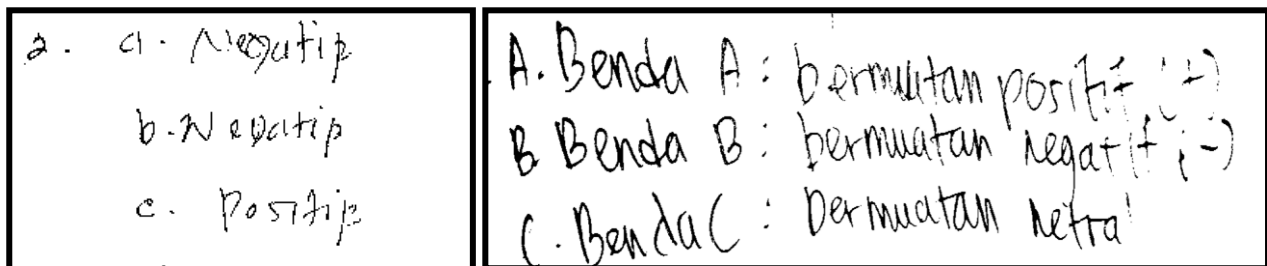


Figure 9. Example of Answers to Question Number 2 with the Lowest Scores in the Control Class (left) and the Experiment Class (right)

Figure 9 compares the answers to question number 2, which measures aspects of flexibility in the control class and the experimental class with the lowest score, 2. As many as 39% of the control class students got the lowest score, and 25% in the experimental class. In comparison, examples of student answers with the highest scores can be seen in Figure 10.

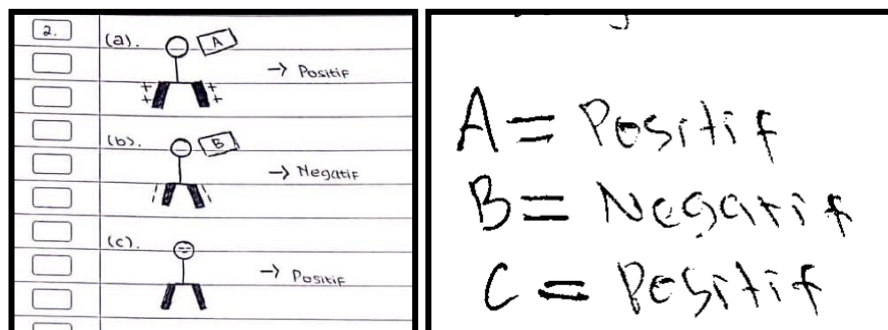


Figure 10. Example of Answers to Question Number 2 with the Highest Score in the Control Class (left) and the Experiment Class (right)

Figure 10 shows the answers to question number 2 with the control and experimental classes with the highest score of 3. As many as 75% of students from the experimental class got the highest score, while in the control class, only 61%. Based on the analysis of students' answers to question number 2, it can be seen

that most of the students have understood the concept of interpreting images on an electroscope. Question number 2 can assess the aspect of flexible thinking where students are required to interpret an image. This result follows the research of [Sukadi and Sari \(2013\)](#), which states that the interaction between charges is one of the materials that get the highest misconceptions.

Question number 1 relates to originality, with indicators of original thinking as having a solution to a problem. Students are asked to analyze the right steps to change an object's charge. The comparison of the answers of the experimental class and control class students on question number 1 can be seen in [Figure 11](#).

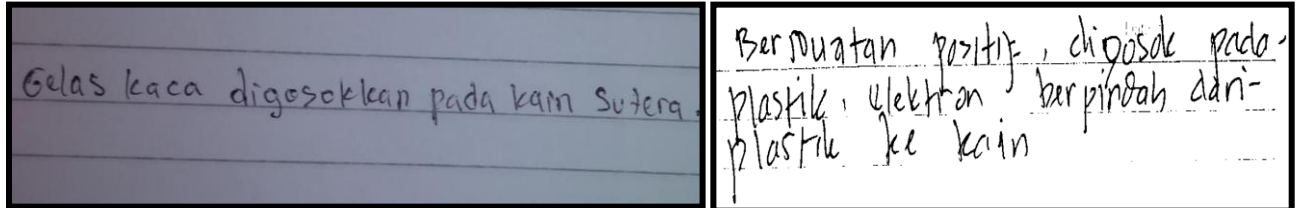


Figure 11. Example of Answers to Question Number 1 with the Lowest Scores in the Control Class (left) and Experiment Class (right)

[Figure 11](#) compares the answers to question number 1, which measures the originality aspect. 16% of control class students received the lowest possible score of 1, while 59% of experimental class students received the lowest possible score of 2. The number of control class students who got low scores was because students could not think of unusual ways, the subject had not been able to make combinations-unusual combinations of available parts in the problem ([Ekawati & Adirakasiwi, 2019](#)). In contrast, examples of student answers with the highest scores can be seen in [Figure 12](#).

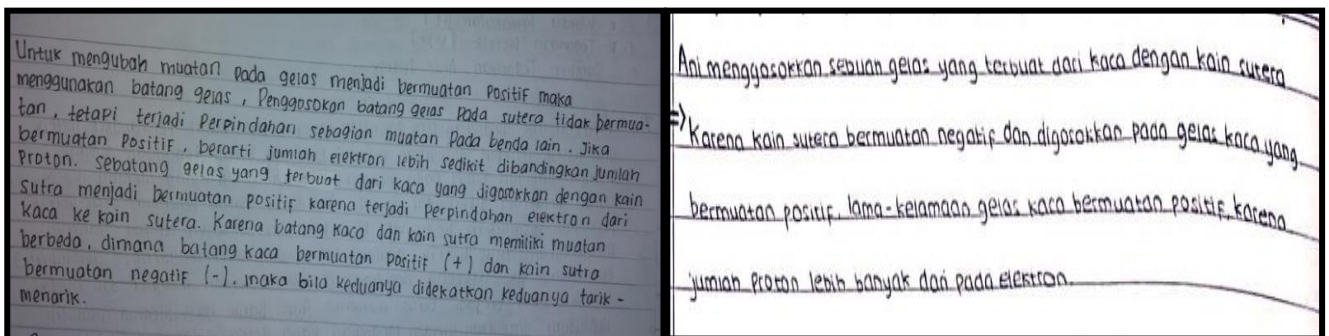


Figure 12. Example of Answers to Question Number 1 with the Highest Score in the Control Class (left) and the Experiment Class (right)

[Figure 12](#) shows the answers to question number 1 in the control and experimental classes with the highest score of 3. As many as 41% of the experimental class students got the highest score, while in the control class, only 29%. Based on the analysis of answers to question number 1, some students wrote incorrect answers due to misconceptions. This result follows the research of [Sukadi and Sari \(2013\)](#), which states that a misconception that often occurs in static electricity is of them regarding the transfer of charge from both glass and plastic materials.

While both experimental and control classes saw an increase in students' creative thinking abilities, a hypothesis test utilizing the t-test was used to examine the difference in efficacy between the two classes. The independent t-test presented in table 4 obtained the value of Sig. of 0.002. Based on the independent t-test decision making, it was concluded that H_0 was rejected, which means that there is a difference in the average value of the experimental class that applies PjBL-Low Carbon STEM and the control class that applies discovery learning. In addition, the average difference shown in table 4 shows that PjBL-Low Carbon STEM can improve students' creative thinking skills.

PjBL-Low Carbon STEM requires students to solve a problem using a project ([Capraro et al., 2013](#)). PjBL-Low Carbon STEM and discovery learning help students improve their creative thinking skills, but they work in different ways. In classes that use PjBL-Low Carbon STEM, students learn about real-world problems and then design and do a project to solve them. The project in this study also helps students learn about sustainable development because they make STEM projects that are environmentally friendly or use less energy. Students make simple voltaic cell projects with things already around, like manga, potatoes, starfruit, and tomatoes. The students in the experimental class worked on a project that can be seen in the picture, [Figure 13](#).



Figure 13. Example of Low Carbon Project

In addition to the average score difference between the experimental and the control classes, the difference in creative thinking skills can be seen in the n-gain score. The n-gain score for the experimental class is 0.275, while the control class is only 0.126. The results of the n-gain score show that the n-gain of the experimental class that applies PjBL-Low Carbon STEM is greater than the n-gain of the control class with the discovery learning model. The results obtained following [Kristiani et al. \(2017\)](#); & [Mawarni and Sani \(2020\)](#), showed a significant effect of the PjBL-STEM model on creative thinking skills. Research conducted by [Akhmad et al. \(2020\)](#) also state that PjBL-Low Carbon STEM is more effective for improving creative thinking skills. PjBL-STEM can improve 21st-century skills: innovation skills and flexibility skills ([Baran et al., 2021](#)). The phase of the PjBL-STEM model is reflection, research, discovery, application and communication ([Laboy-Rush, 2010](#)). The stages in PjBL-Low Carbon STEM can develop skills through projects designed and proven by themselves. Students' activities in each phase of the PjBL-Low Carbon STEM can improve creative thinking skills, including the first phase namely reflection can develop aspects of flexibility; students interpret the problems contained in the learning video played by the teacher regarding global warming and the energy crisis through this stage. Second phase is research can develop fluency; at the research stage, students are fluent in conveying ideas and answering various questions submitted by the teacher and completing assignment books related to future electrical designs.

Third phase is discovery can develop aspects of fluency, flexibility, and originality. In fluency, students design projects related to the problems given on worksheets regarding the acquisition of abundant fruits and vegetables in a village, but there is still a shortage of electrical energy in that village. While on flexibility, each group designs different projects to find solutions to the problems presented. In originality, students design projects after searching for information by reading from various online and offline sources. Fourth phase is applications can develop aspects of fluency, flexibility, and originality. In the aspect of flexibility, students test the product designed in the assignment book so that they will think of a unique way of testing the product. In the originality aspect, students complete the testing phase after trying the product several times and looking for the correct source of information so that the project design can be successful when tested. Fifth phase is communication can develop aspects of fluency and originality. In the fluency aspect, students present the results of projects that have been tested so that students develop aspects of fluent thinking in making presentations. While in the originality aspect, students improve the product and complete it after getting suggestions and input from the teacher or other groups.

PjBL-Low Carbon STEM requires students to learn scientifically through reading, writing, observing, and working on projects to be used to solve real problems ([Lestari et al., 2018](#)). This result is different from the learning carried out in the control class, which uses a discovery learning model and does not carry out project creation activities. Differences in student activities carried out in the control class, and the experimental class can be seen in [Table 3](#).

Table 3. Comparison of Learning Phases in Control Class and Experiment Class

Learning in the Control Class	Learning in the Experiment Class
Stimulation Students are given stimulation using videos about global warming and the energy crisis.	Reflection Students are brought to the problem by showing global warming videos and the energy crisis.
Problem Statement Students identify problems based on videos at the stimulation stage and ask the teacher questions about the problem.	Research Students are brought to the problem by showing global warming videos and the energy crisis.
Data Collection Students search for information related to the LKPD given by the teacher.	Discovery Students design their projects based on existing problems.
Data Processing Students discuss with their groups to analyze the data that has been obtained.	Application Students make products that have been designed and carry out product testing.
Verification Students present the results of the discussion in front of the class.	Communication Students communicate the results of making projects in front of other groups.
Generalization Students and teachers make conclusions from the learning that has been done.	

The application of PjBL-Low Carbon STEM in the experimental class improves students' creative thinking skills and instils the concept of being environmentally friendly (low carbon). Electrical material is very closely related to real-life; therefore, through project-based learning, it is hoped that students can solve problems that exist in real life (Sumarni et al., 2019). The STEM approach, which is integrated with the PjBL, allows students to learn scientific concepts closely related to real-life and provide direct experience, and students are not just memorizing concepts (Herak & Lamanepa, 2019). The integration of low carbon education in the learning process is intended to teach students to be environmentally friendly, considering that excessive use of electricity can cause global warming. The purpose of integrating low carbon in learning is supported by students' positive responses, who stated that after the learning process using PjBL-Low Carbon STEM, students' behaviour and practices were environmentally friendly (low carbon) increased.

The implementation of PjBL-Low Carbon STEM cannot be separated from the obstacles faced. At the beginning of learning, some students did not follow proper procedures and syntax because PjBL-Low Carbon STEM was very new. However, after a while, the students followed the lesson very well. Even when asked to conduct discussions, many students gave suggestions and arguments for the designed project. Another obstacle is related to school facilities and infrastructure. One of the tools used in electricity learning is a voltmeter. The school's laboratory equipment's limitations are because the school's laboratory equipment is still in the old location. In the project that was carried out, it was supposed to use a tool to measure voltage, but because the school's location moved, the school did not have a voltmeter. So the amount of voltage generated is not calculated but is overcome by calculating the amount of material needed to turn on the lights.

The factor that caused as many as 56% of students to be more enthusiastic about participating in science learning after applying the learning model was the creation of projects that became a new experience for students. When the Covid-19 pandemic took place, teachers did not prioritize practicum or direct project creation; this caused learning to become bored, so when students were asked to make projects or practicums directly, it could increase enthusiasm and motivation to learn. Insyasiska et al. (2015) found that project creation can increase students' learning motivation.

Students' response to the low carbon concept integrated into the learning process is excellent, whereas many as 54% of students better understand the principles and attitudes of low carbon after learning, and as many as 55% of students will carry out low carbon practices at home. Environmentally friendly education must prioritize the concept of low carbon because energy and carbon emissions are a source of environmental problems that threaten the earth. Low carbon technology is a way to reduce global warming, energy crisis and sustainable development (Lv & Qin, 2016). So that low carbon education must be instilled in students when learning takes place.

CONCLUSION

This study suggests that PjBL-Low Carbon STEM is a more practical approach for developing creative thinking skills. By incorporating the low carbon concept into the learning process, students can better understand the low carbon principles, concepts, and attitudes necessary to reduce carbon emissions. Because the research undertaken thus far has been limited by the researchers' abilities, additional research on the effectiveness of PjBL-Low Carbon STEM in improving creative thinking skills in larger and more profound material should be conducted.

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